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NEW YORK
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go
NA
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ENTUCKY
VIRGINIA
16 hr 8 min
Tolls
NORTH CAROLINA
Atlanta
SOUTH CAROLINA
13 hr 39 min
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1 day
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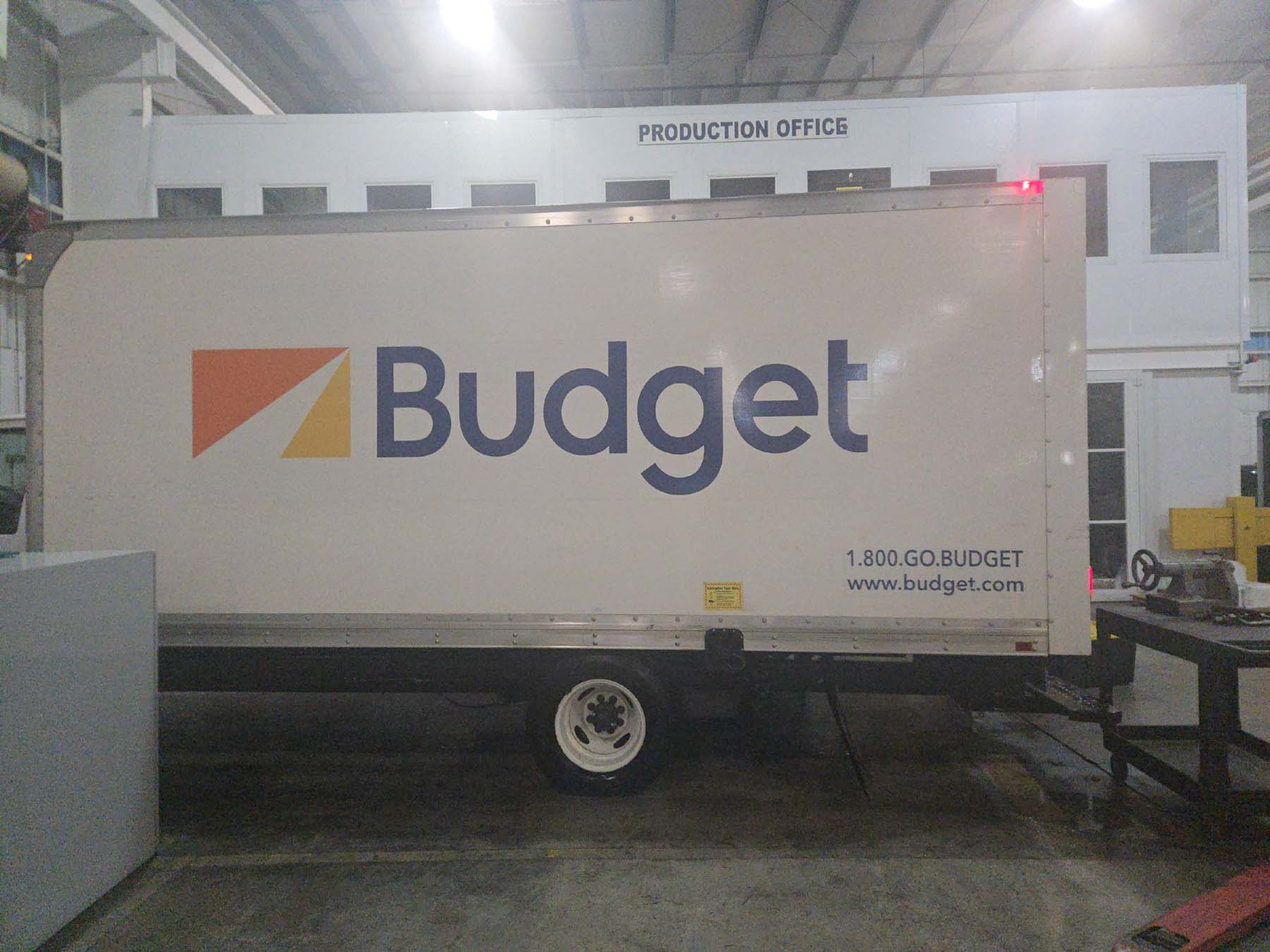
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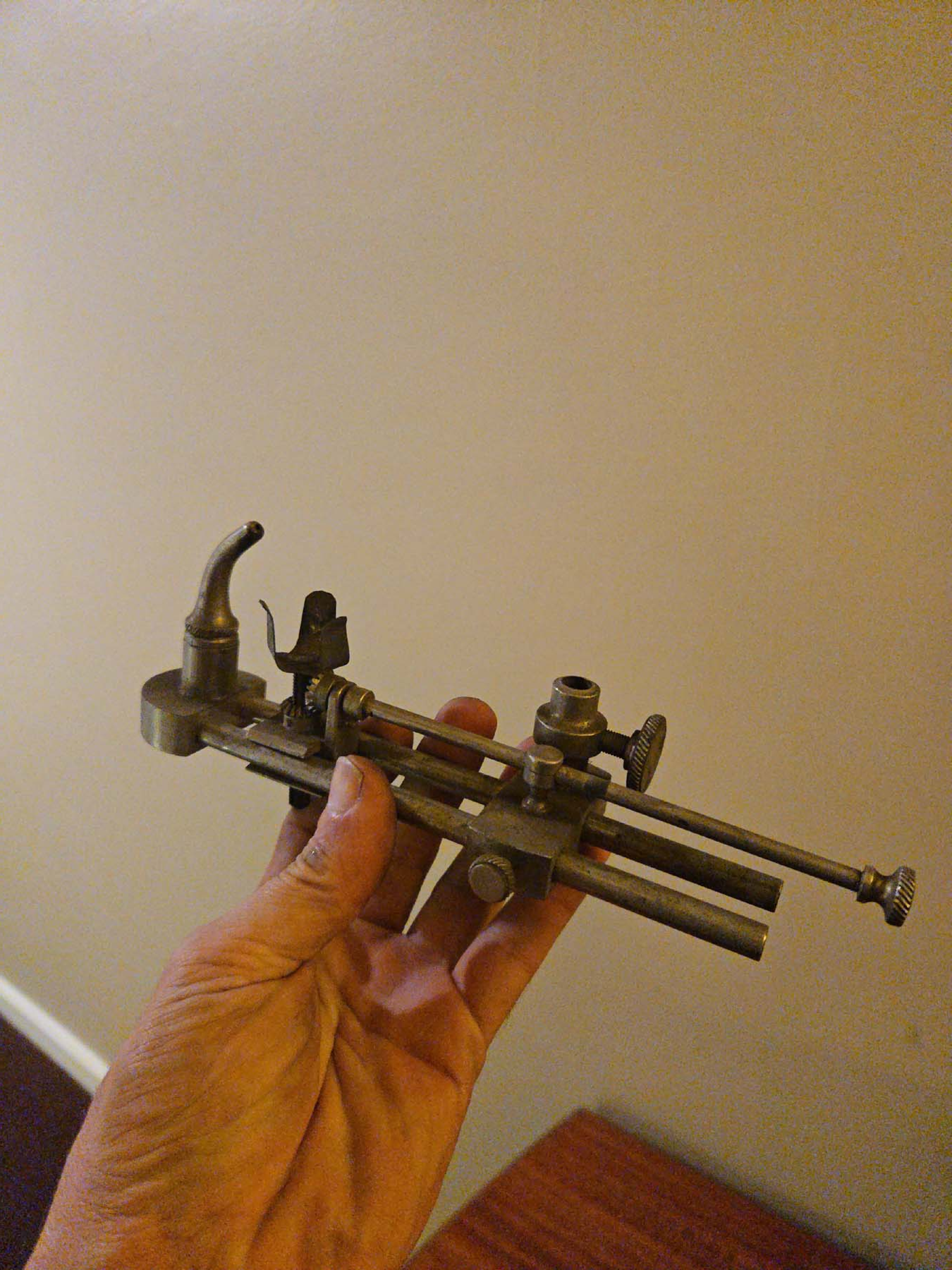

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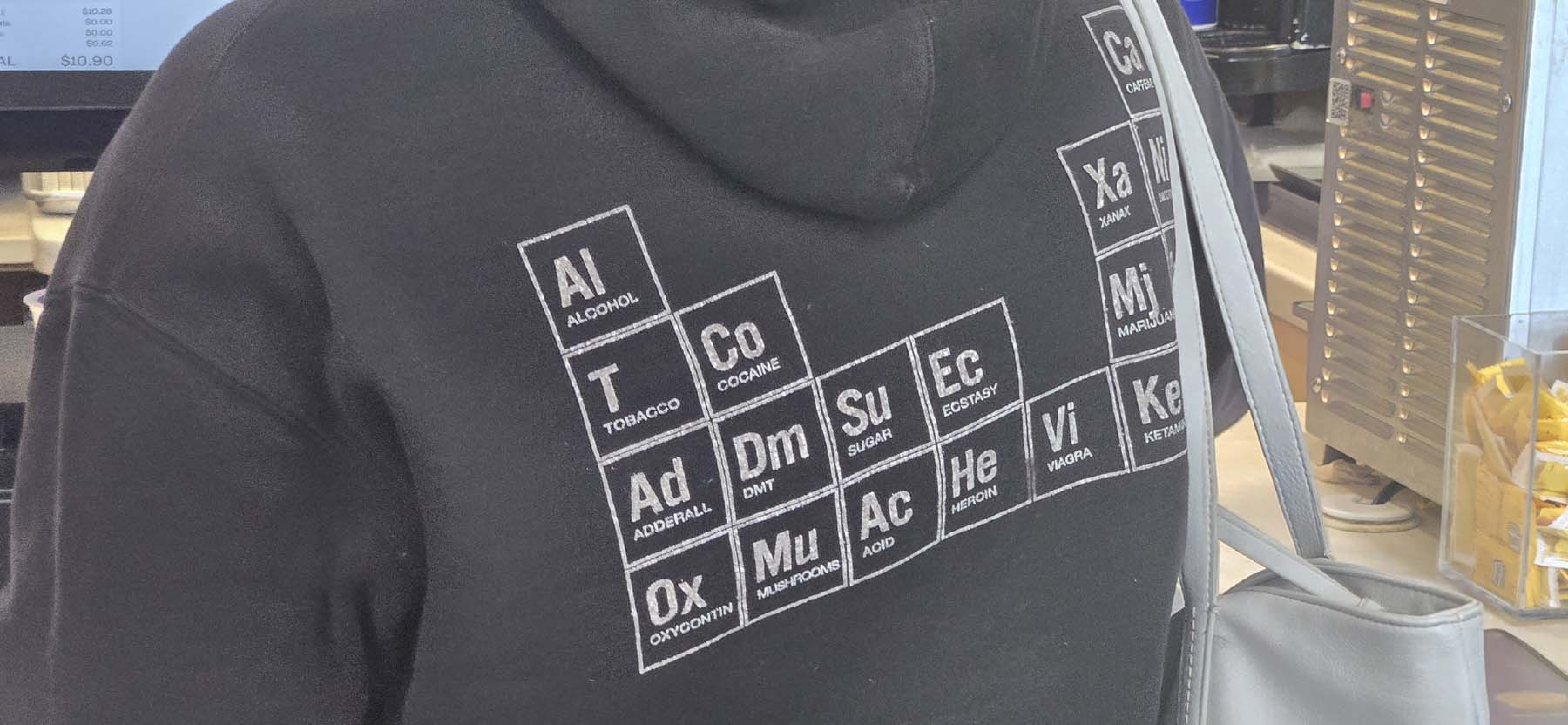
OADING
TOYOTA
6



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KETAM
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HEROIN
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ACID
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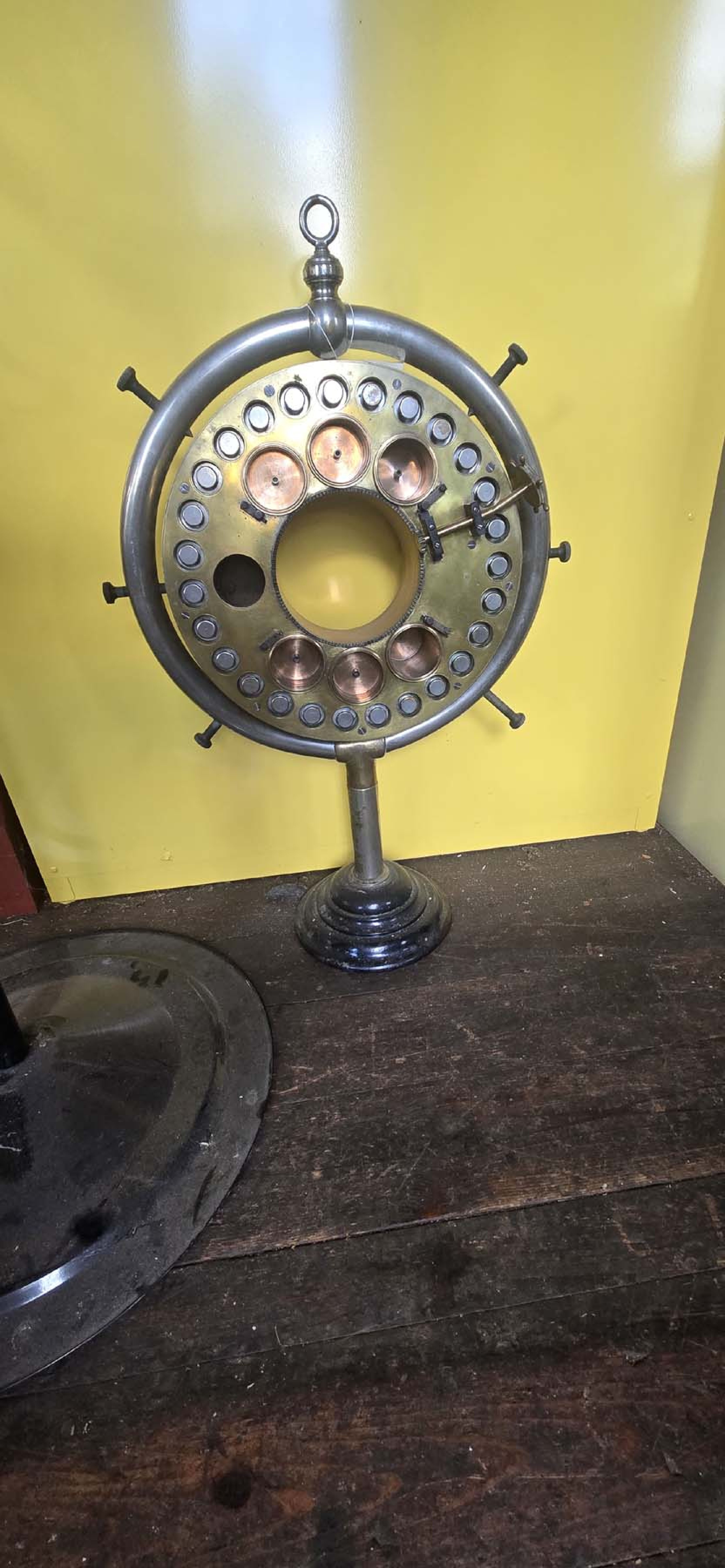
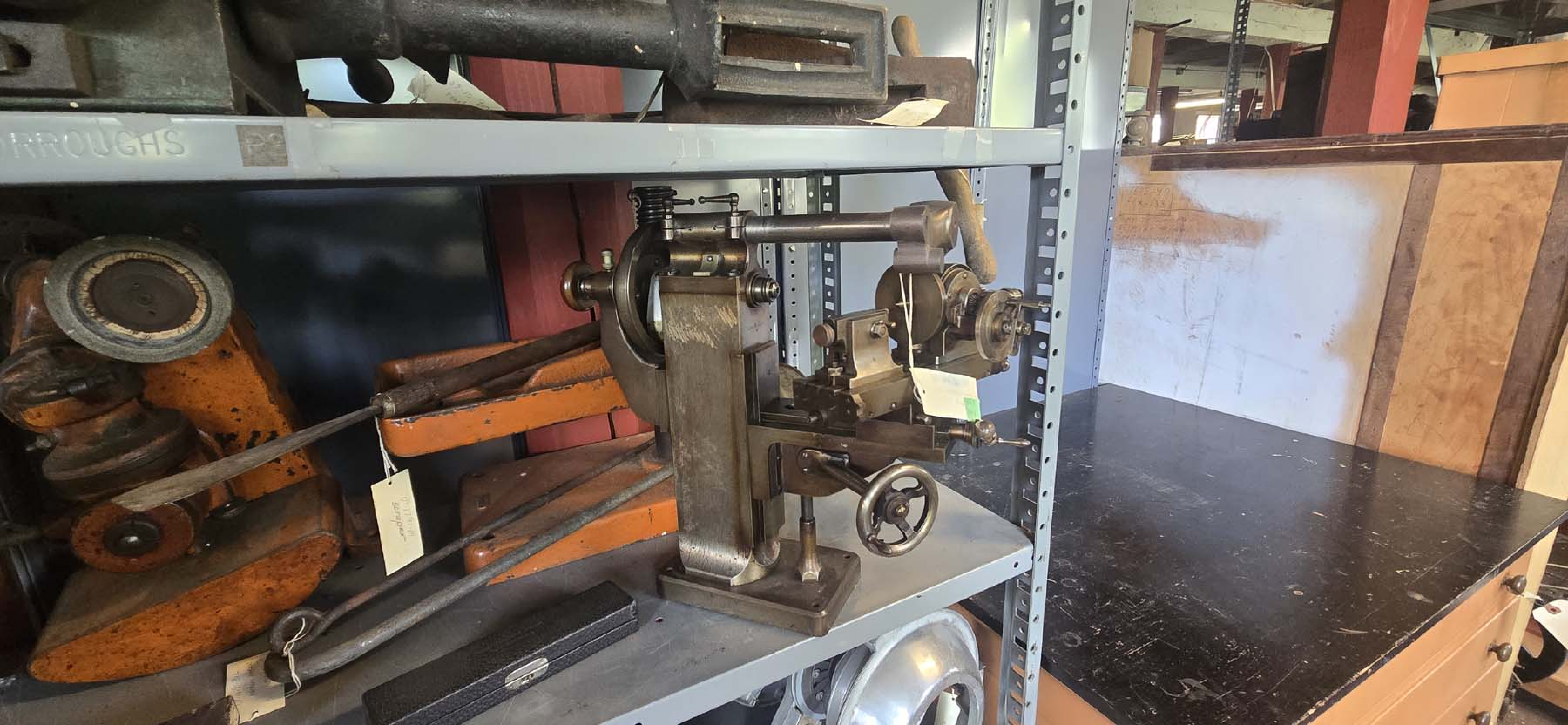
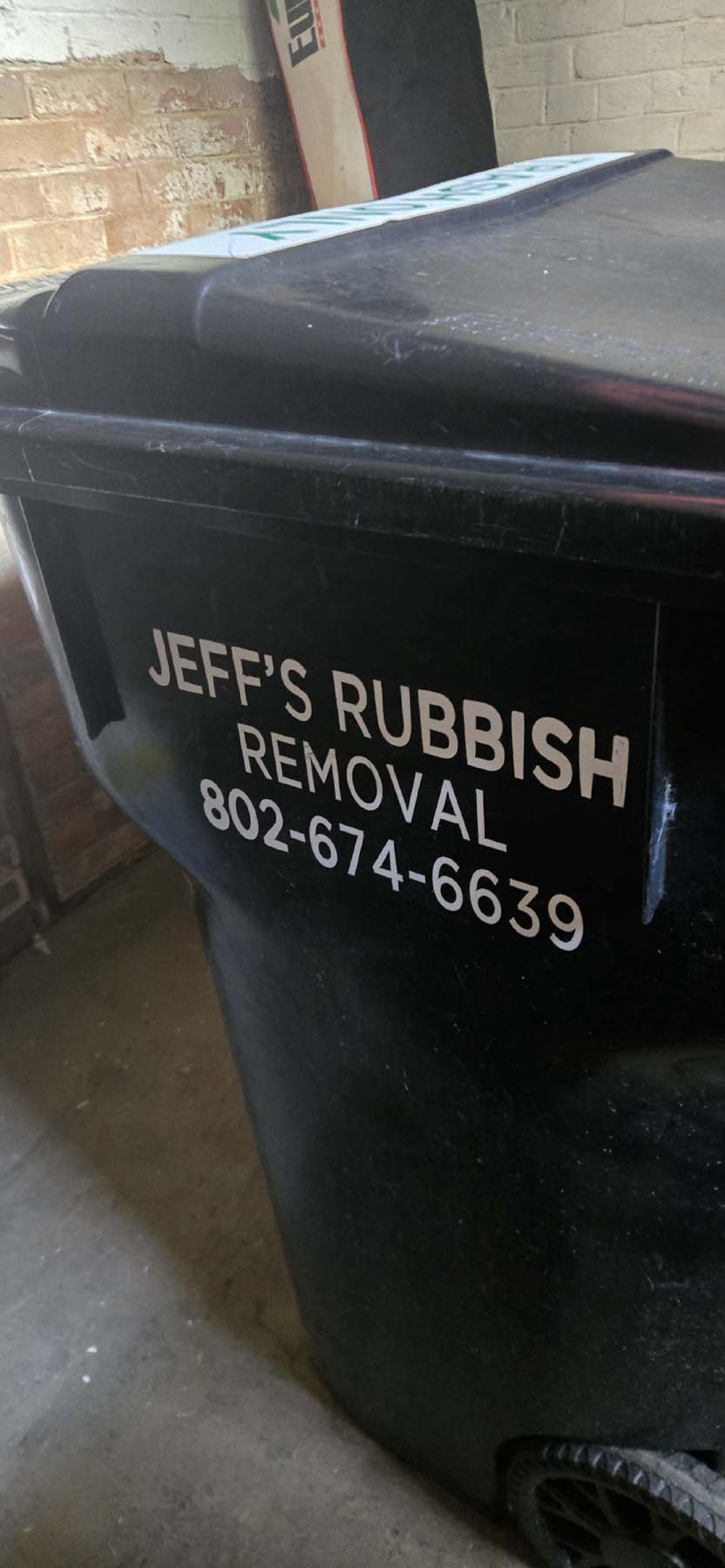
Inn & Suite
WEST LEBANON

花巻市消防団
第一分団第五部




RROUGHS
P2
scraper

1500lb.
CAPACITY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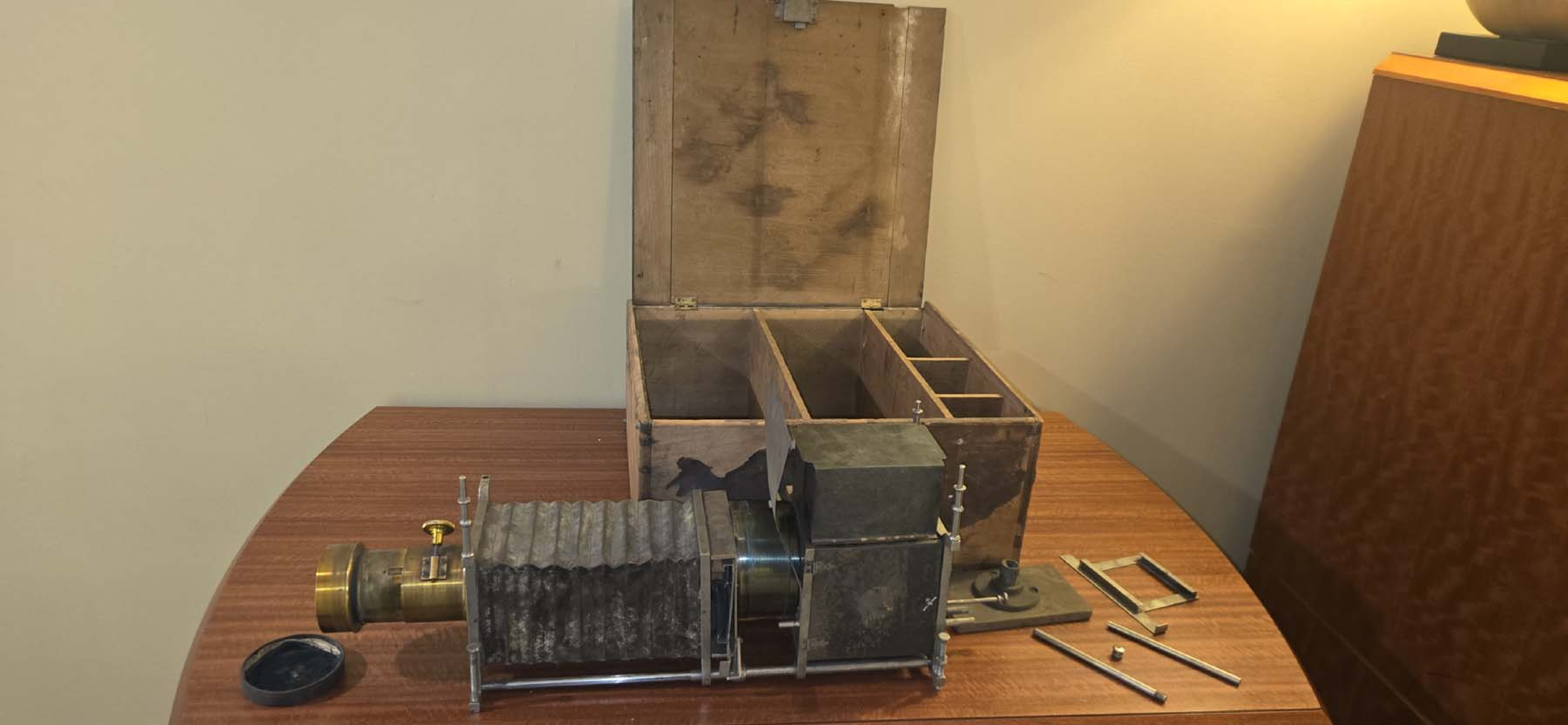

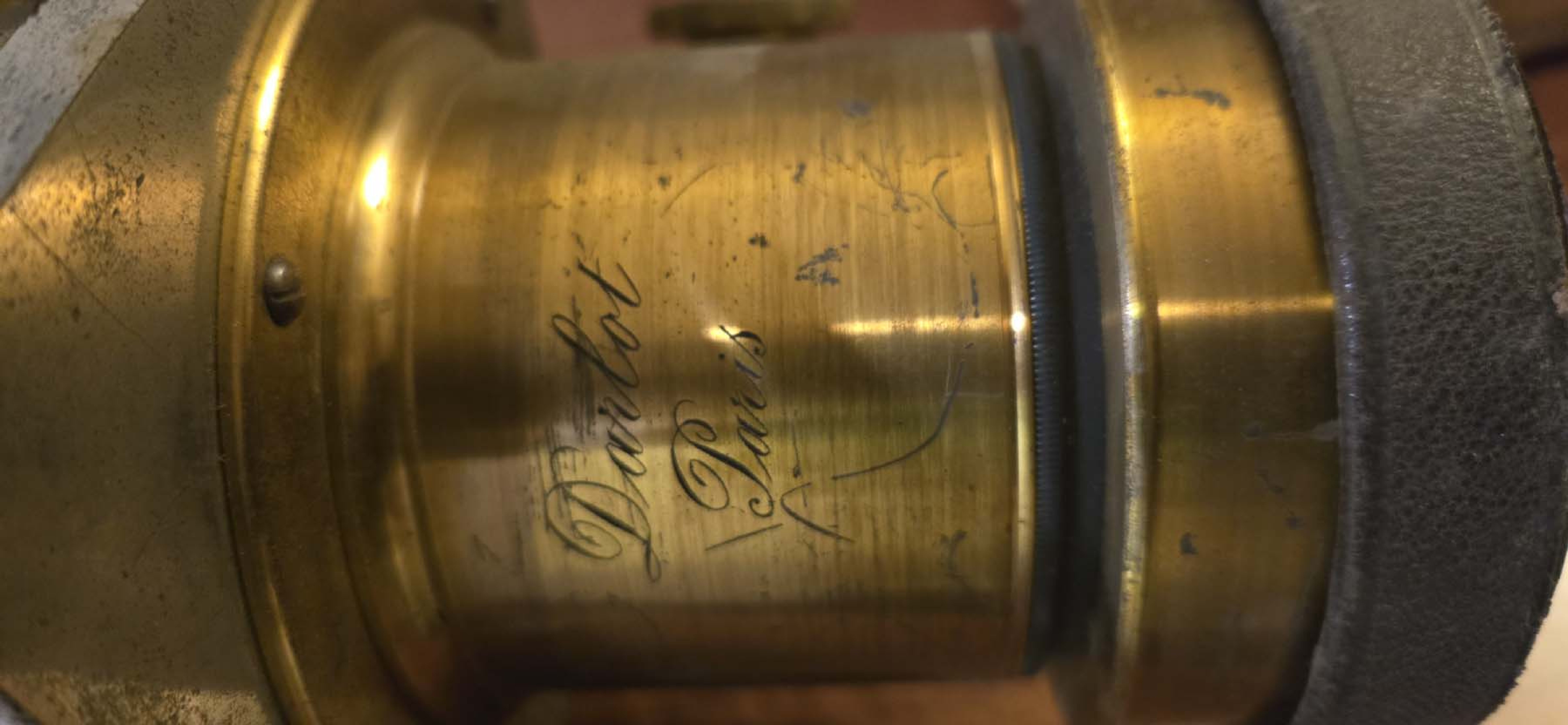
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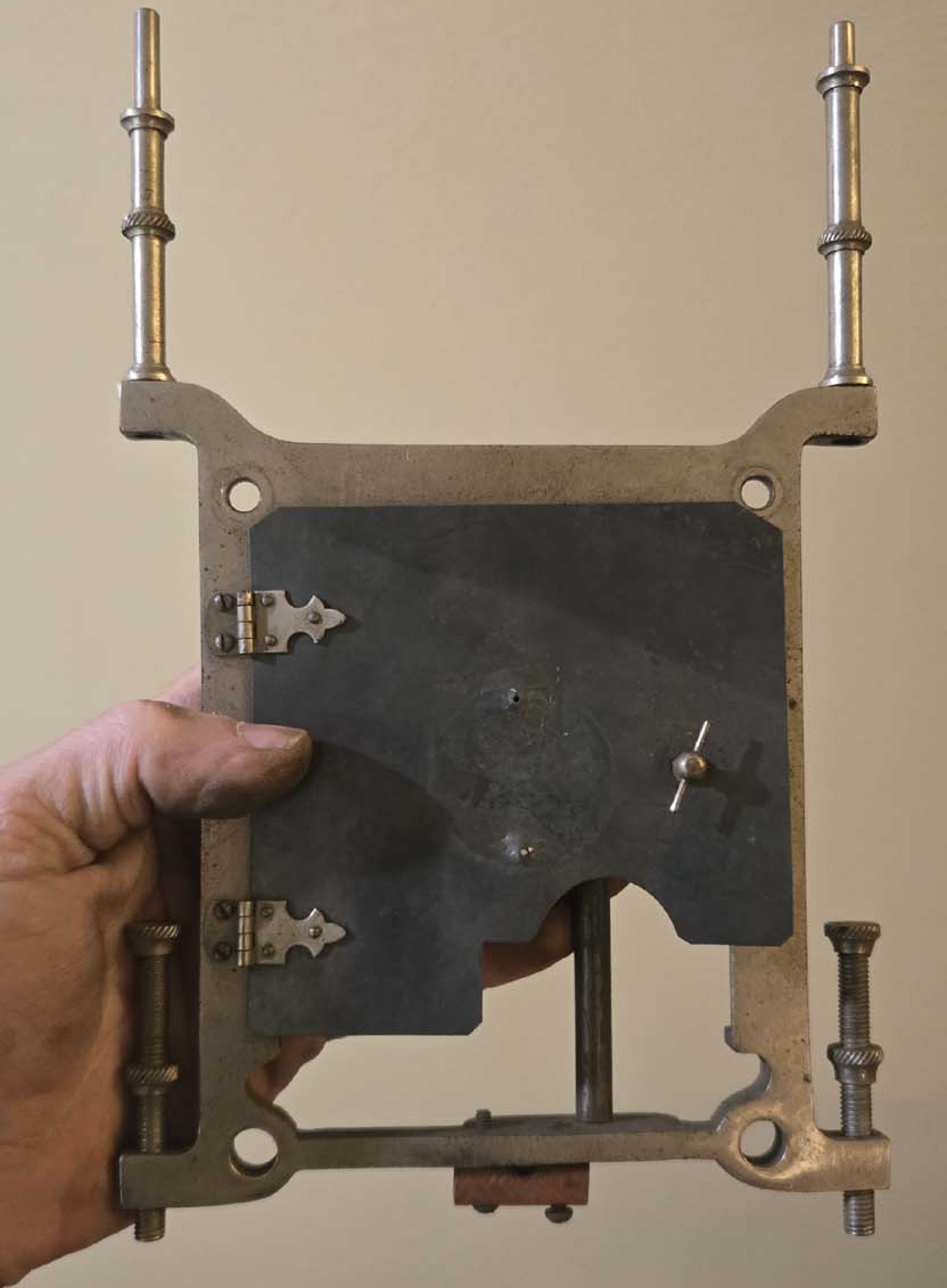

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CATERPILLAR
V300B

"HERCULES"
CATERPILLAR

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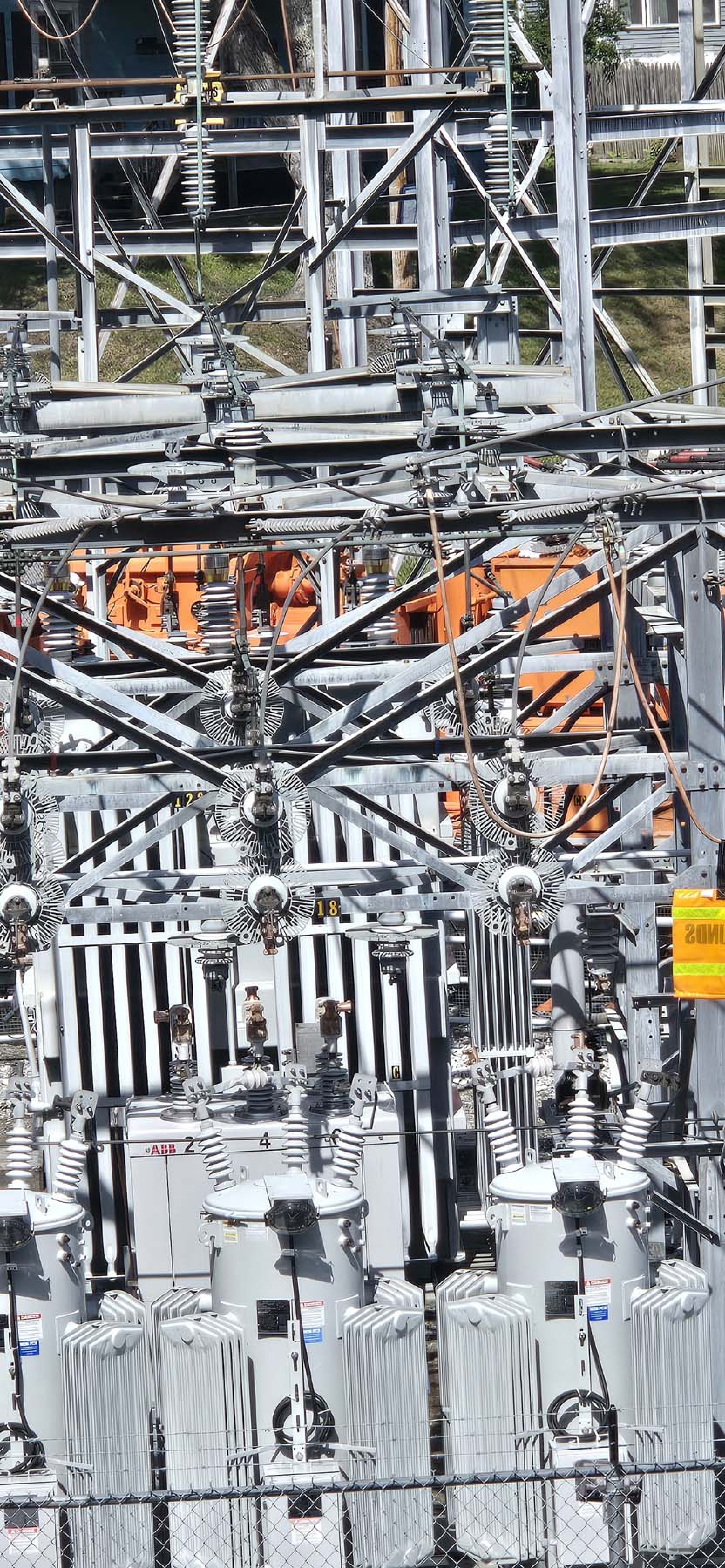
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& Equipment LLC
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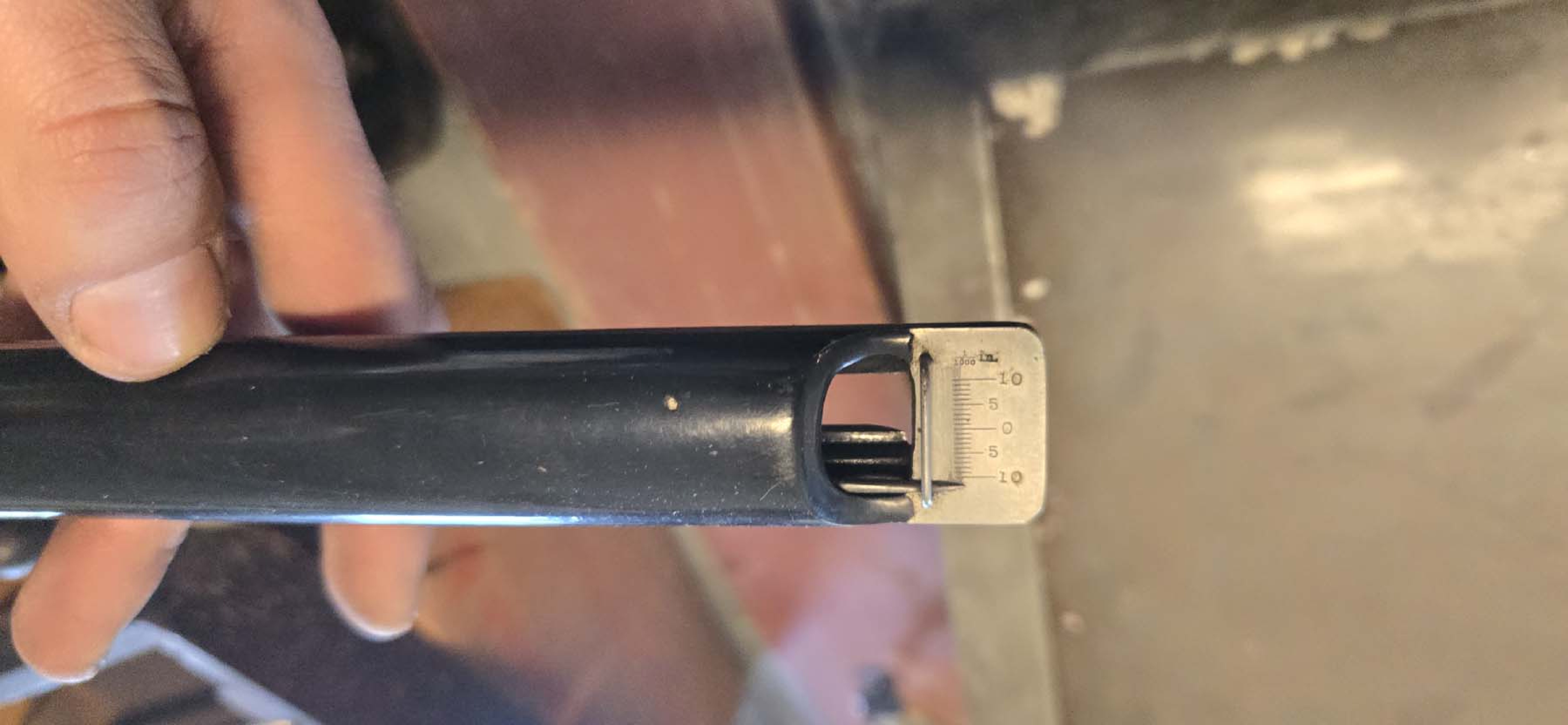
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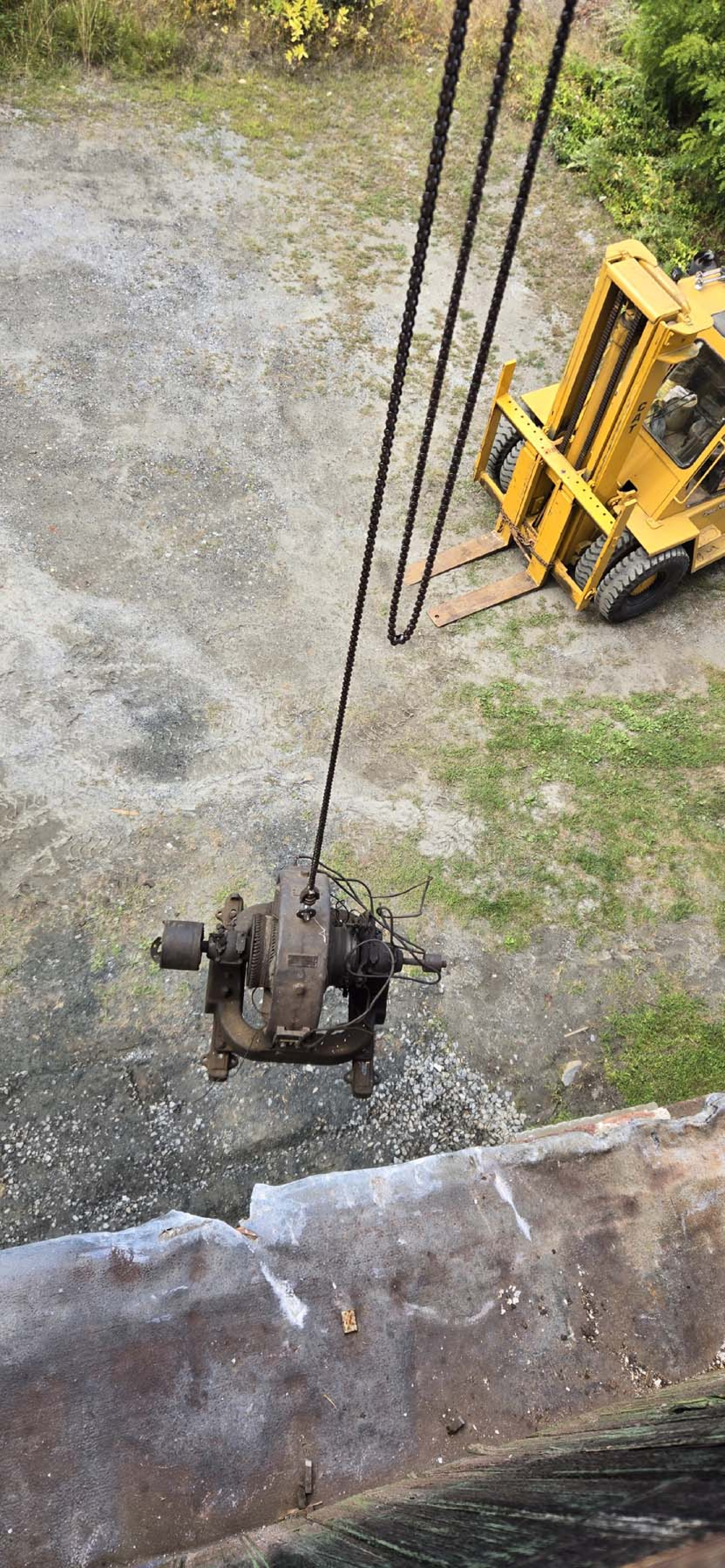
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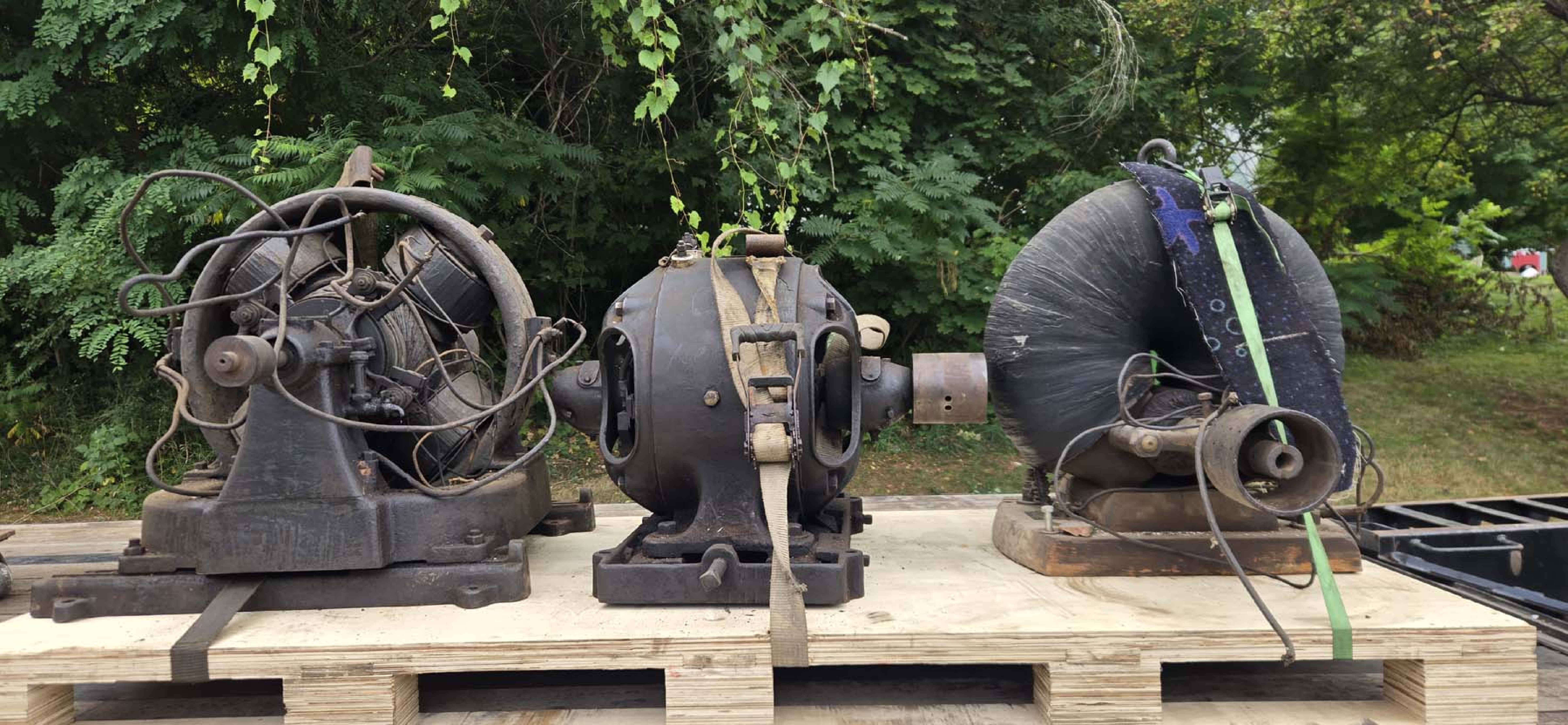
CAT

S.I.T.E.S.
144

SITES
144

BOX 9 OF
14 BOXES
WT. 222 lbs.
SITES
SITES

S.I.T.E.S.
144



FIRE EXTINGUISH
FORT MYERS STATE FARMERS MARKET
DOK BREWING CO

FIRE EXTINGUISH
FORT MYERS STATE FARMERS MARKET
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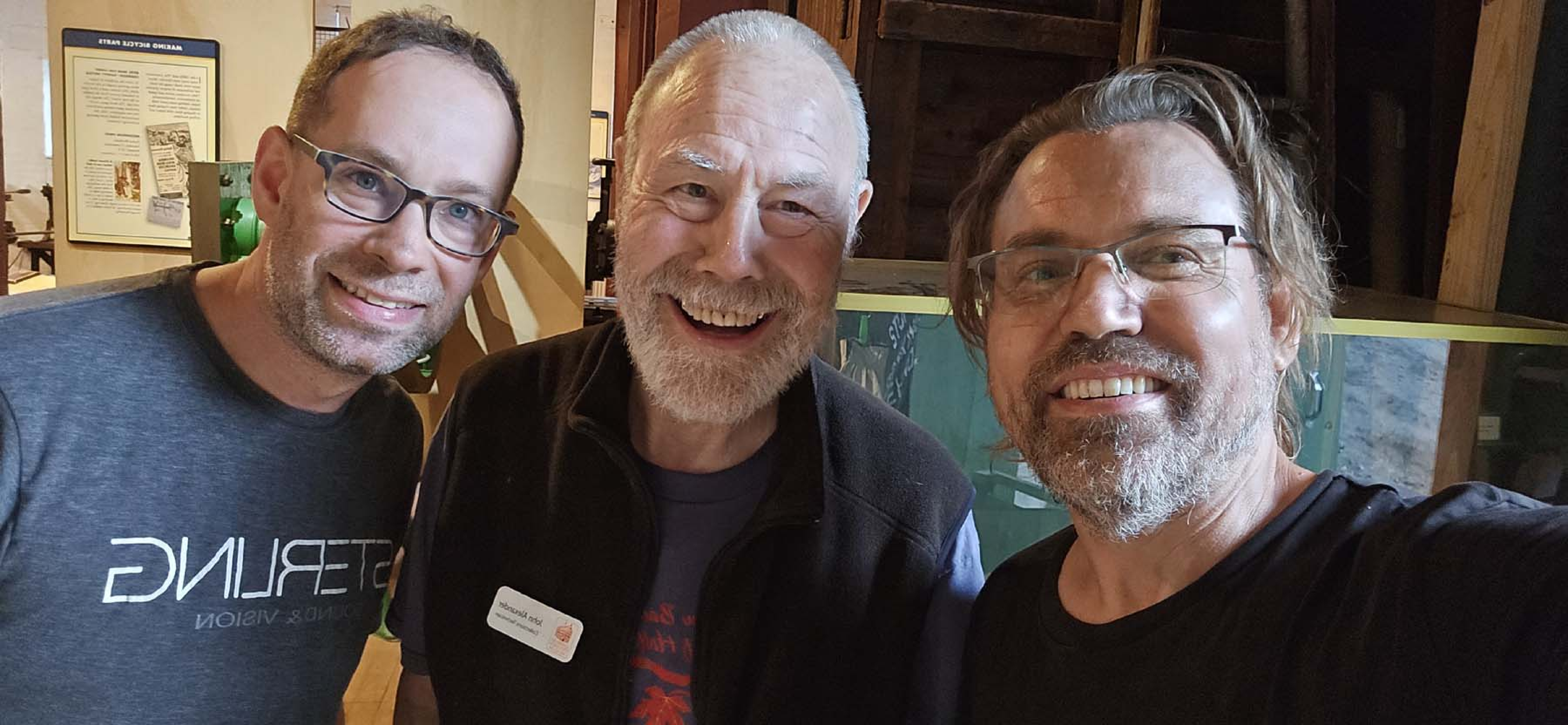
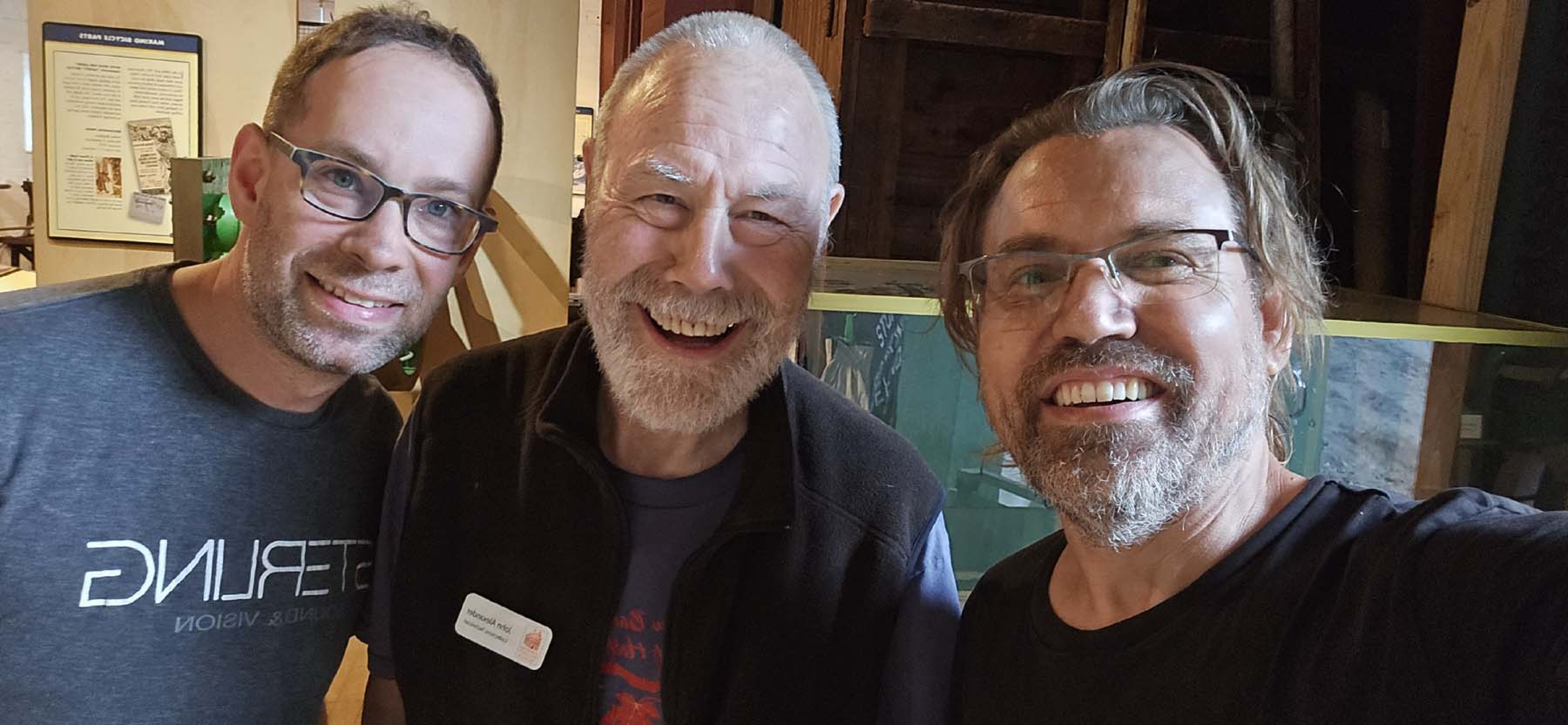

MAKING BICYCLE PARTS
STERLING
SOUND & VISION
John Alexander



27

ÉCLAIRAGE
A
L'ÉLECTRICITÉ

RENSEIGNEMENTS PRATIQUES

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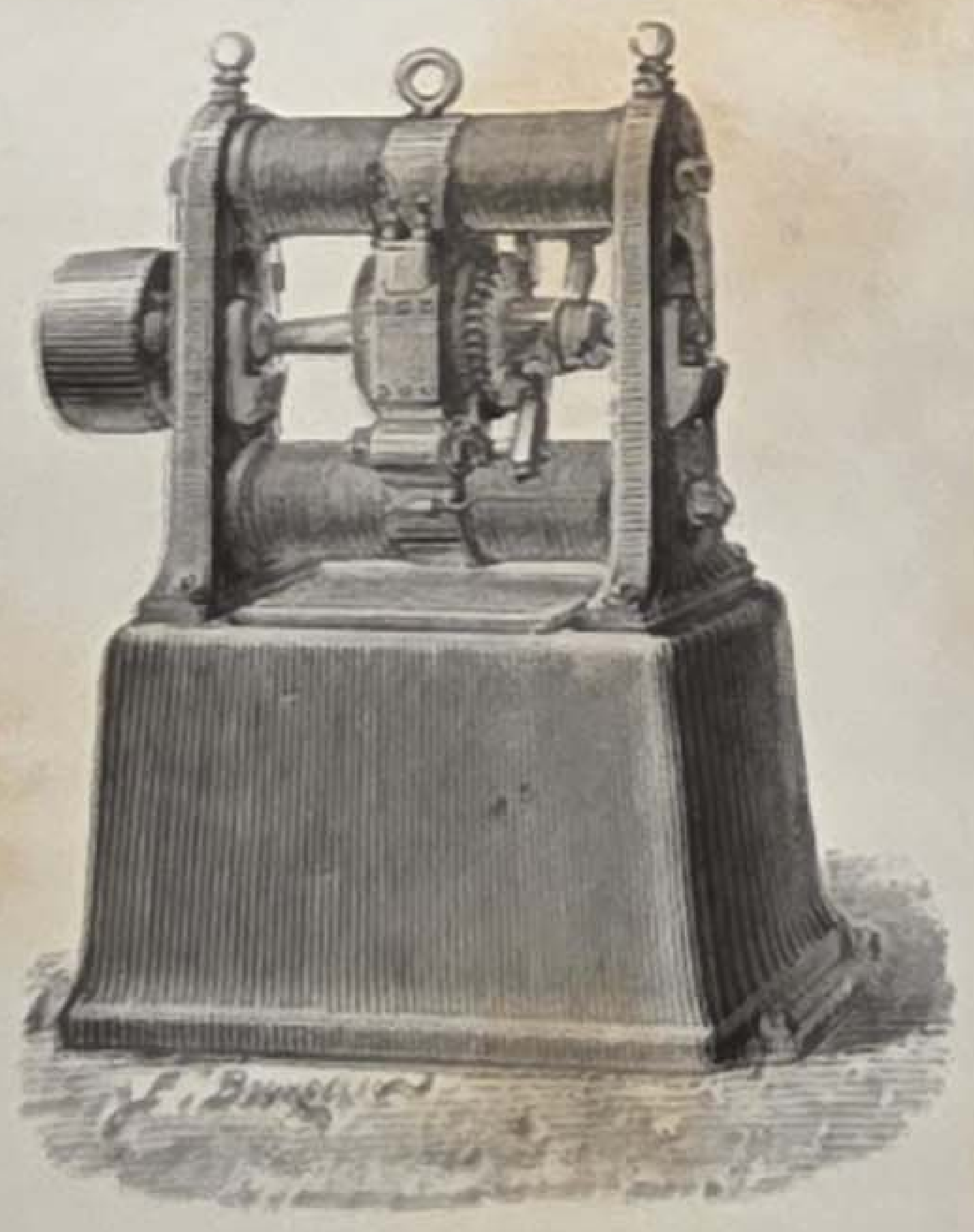
HIPPOLYTE FONTAINE

DEUXIÈME ÉDITION

81 GRAVURES DANS LE TEXTE

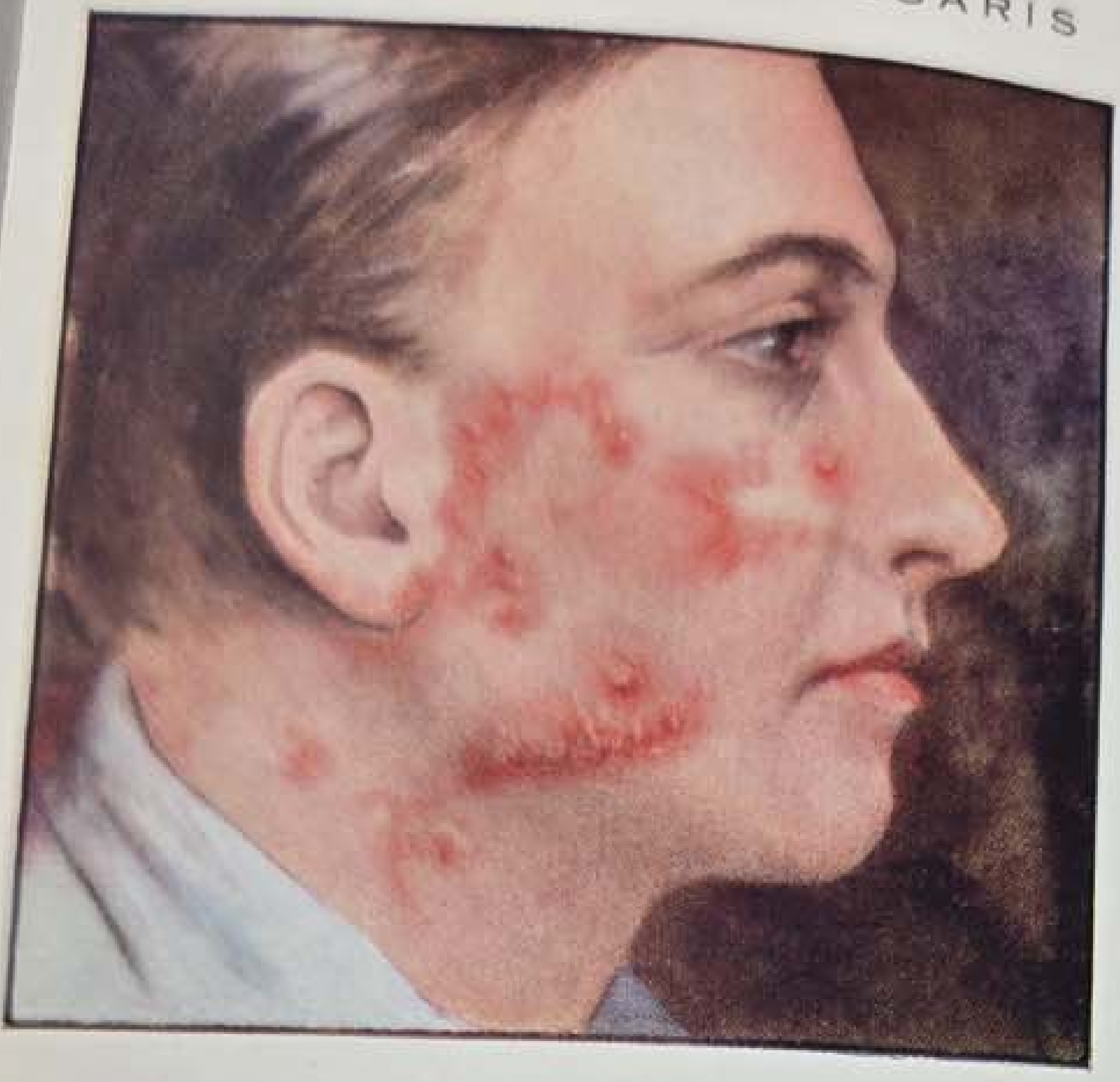


PARIS
LIBRAIRIE POLYTECHNIQUE
J. BAUDRY, LIBRAIRE-ÉDITEUR
RUE DES SAINTS-PÈRES, 15
LIÉGE, MÊME MAISON

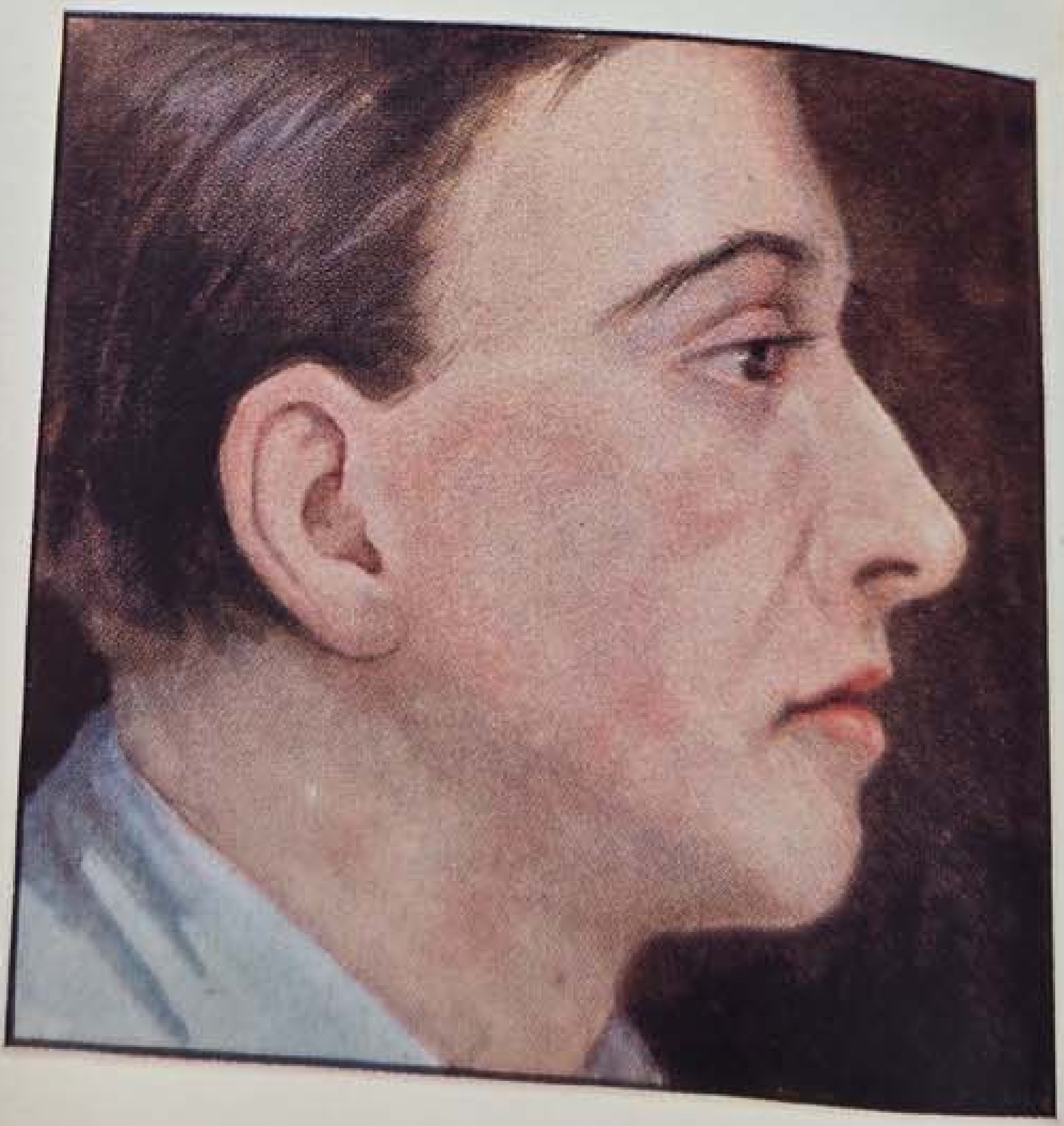
1879

Tous droits réservés

LUPUS VULGARIS



Lesion
before
treatment



Lesion
after
treatment
with
Phenylethyl
Hydnocarpate

See
'EULYKOL'
page 79

THE
ELECTRICAL PROPERTIES
OF FLAMES
AND OF
INCANDESCENT SOLIDS

HAROLD A. WILSON.

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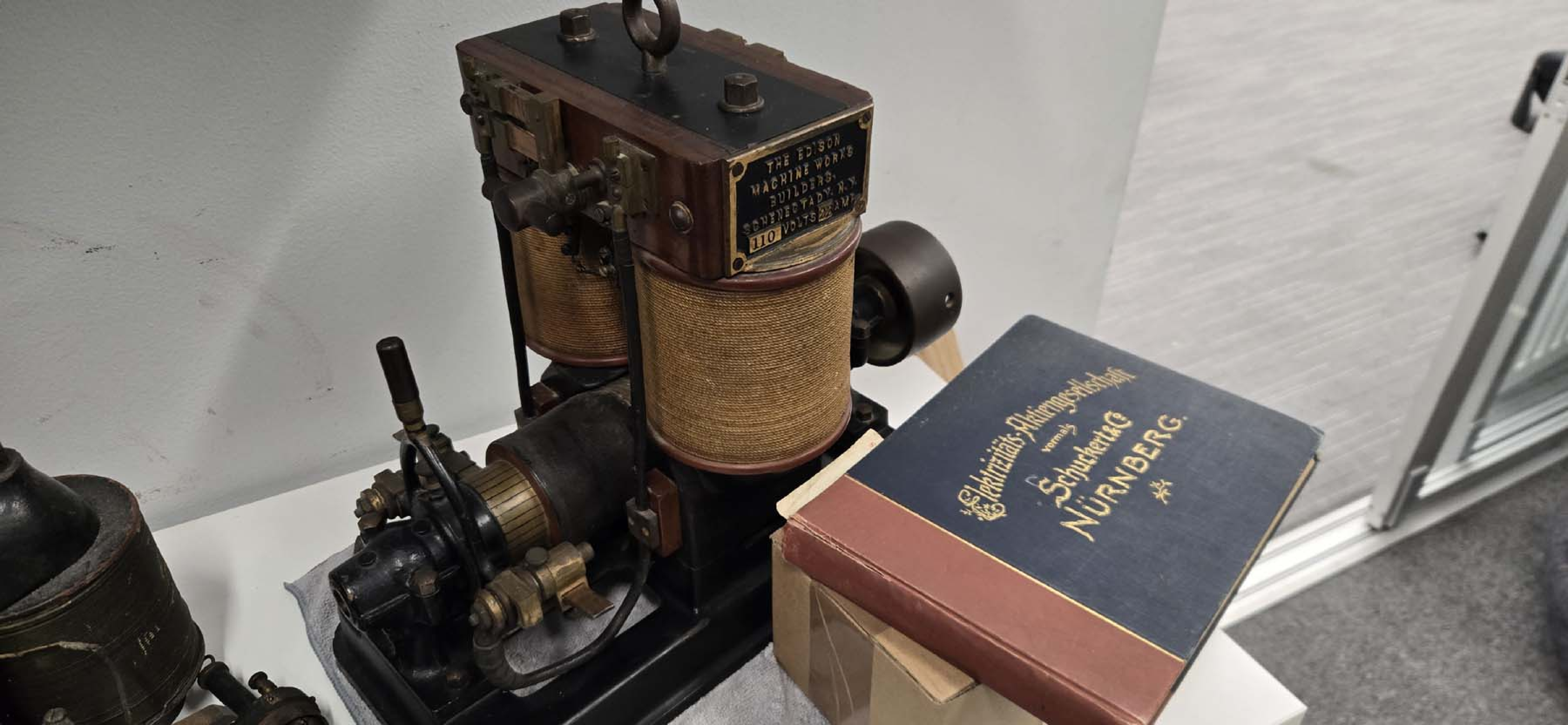
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MACHINE WORKS
BUILDERS.
SCHENECTADY, N.Y.
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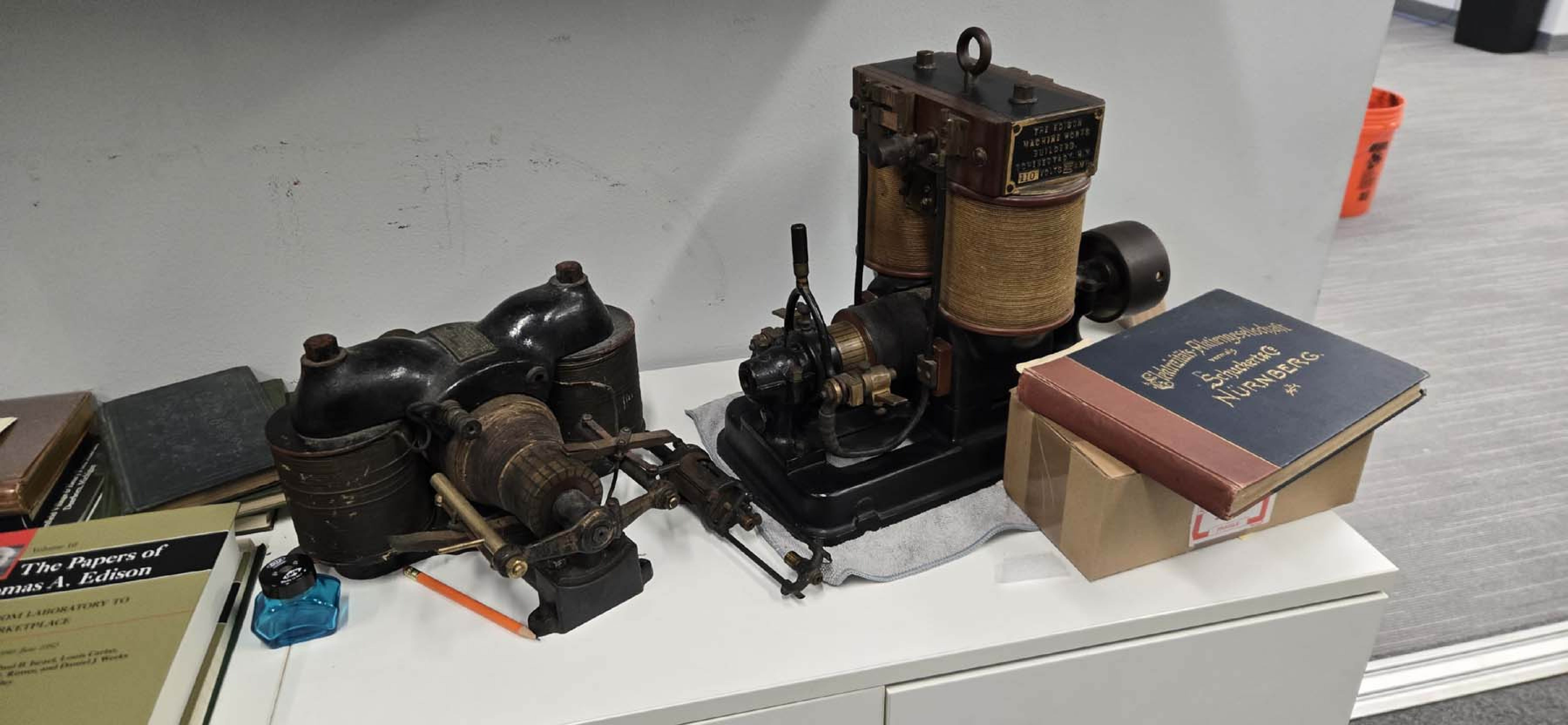
THE EDISON
MACHINE WORKS
BUILDERS
110 VOLTS
NÜRNBERG
The Papers of
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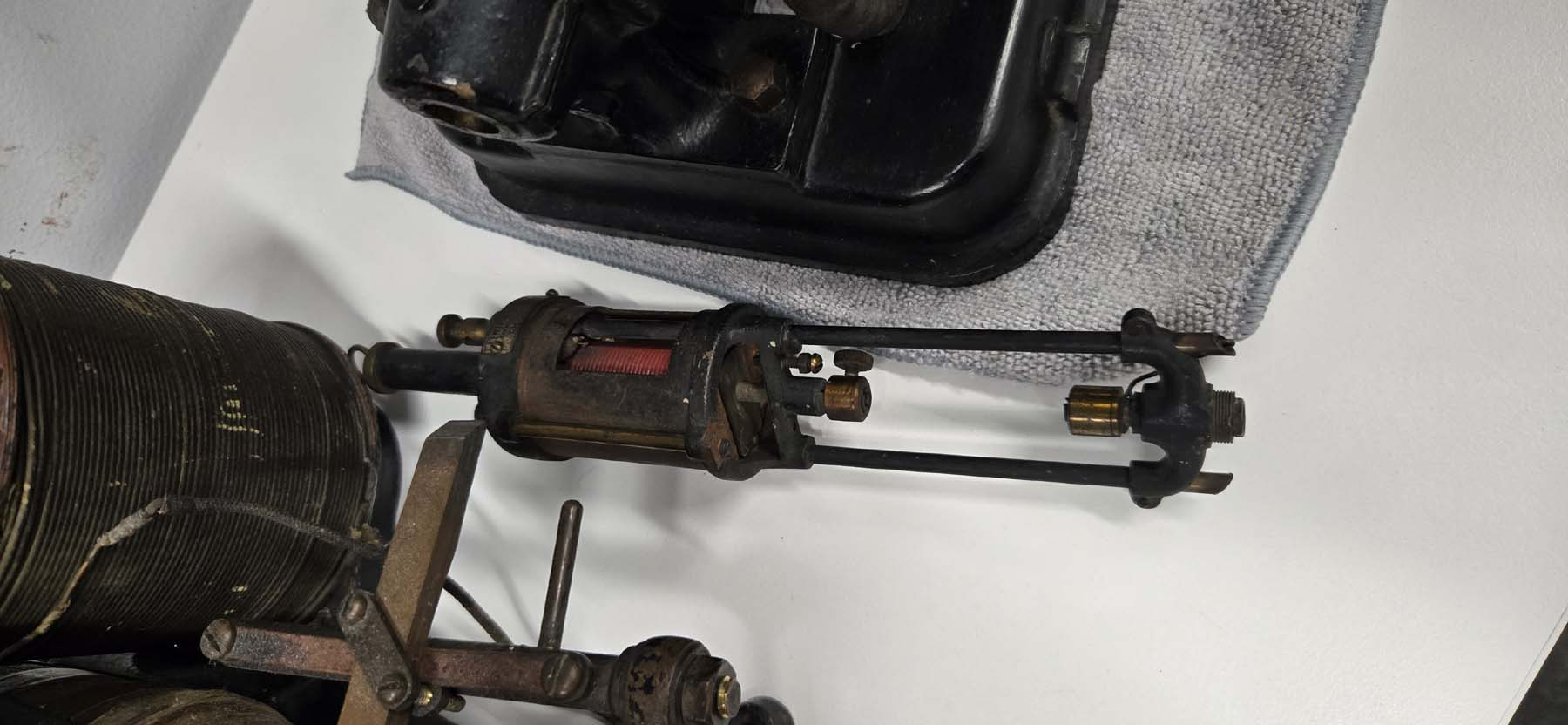

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Electric Lighting 1882
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KNIGHT
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ITS HISTORY PRODUCTION AND APPLICATIONS
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HOUSTON AND KENNELLY
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HOUSTON
ELECTRICITY IN EVERY-DAY LIFE
HOUSTON

Thomas Edison
Hiebert
WATTS
EDISON HIS LIFE AND INVENTIONS
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VOL. I
RIMER
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LYONS PRESS
Vanderbilt
Thomas Edison, Chemist
JOURNAL OF THE SOCIETY OF TELEGRAPH ENGINEERS
VOL. XIII
THE ELECTRIC LIGHT IN ITS PRACTICAL APPLICATIONS
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ELECTRIC LIGHT
ELECTRIC LIGHTING SPECIFICATIONS
MERRILL
McGRAW
ELECTRIC LIGHT
URQUHART
EDITED BY F. C. WEBB
CROSBY LOCKWOOD & CO.
ELECTRIC LIGHT
URQUHART
CROSBY LOCKWOOD & SON
1890.
ELECTRIC LIGHT
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ELECTRIC LIGHTING
ATKINSON
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Price, 25 cents.

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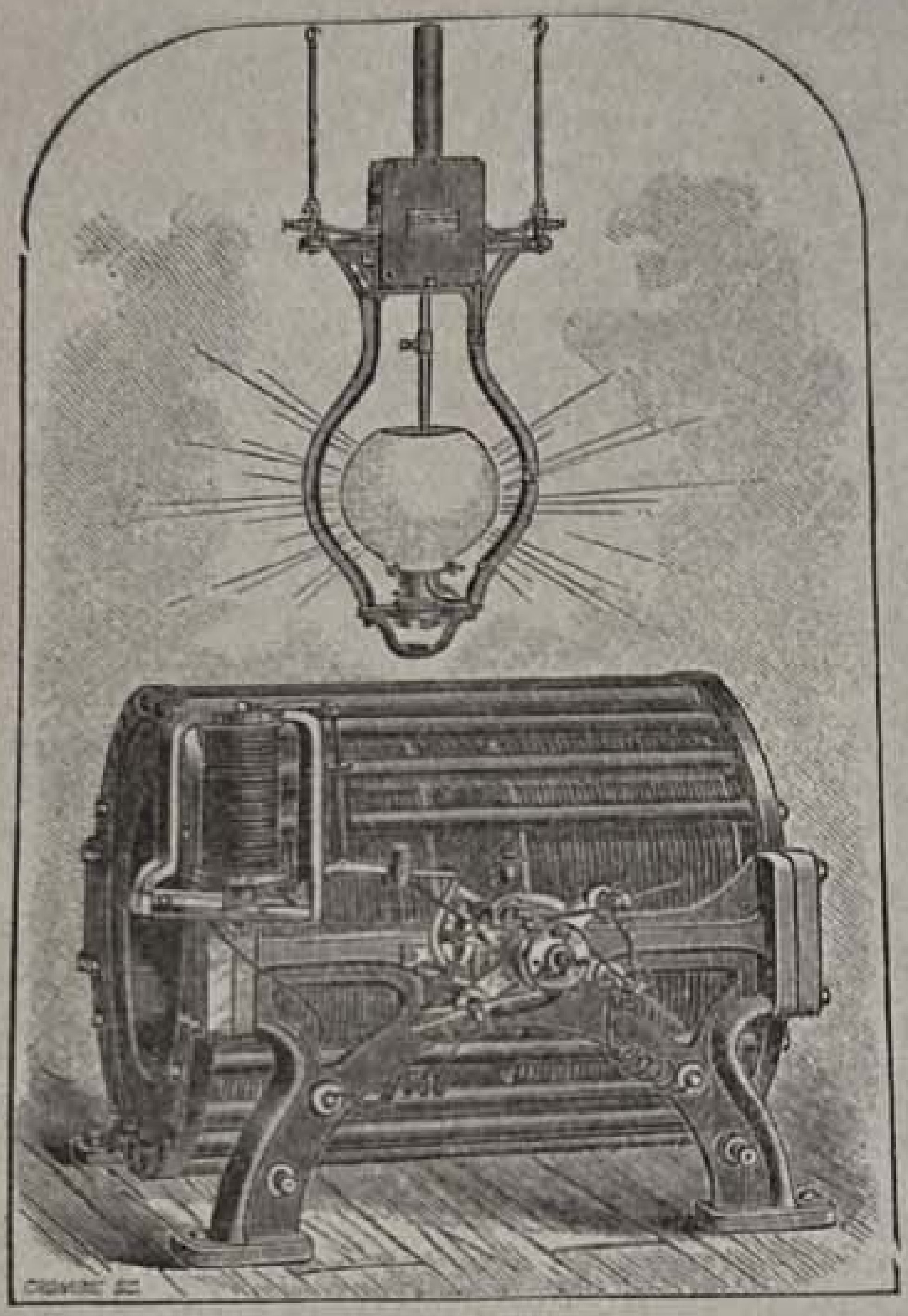

THE ARC AND INCANDESCENT SYSTEMS.

THEIR ORIGIN AND HISTORY.

BOSTON:
PUBLISHED BY THE
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The Papers of Thomas A. Edison
NEW BEGINNINGS
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COMPETING INTERESTS
January 1888–December 1889
Volume 10
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FROM LABORATORY TO MARKETPLACE
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JAMES DREDGE
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JAMES DREDGE
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NORTH AMERICAN REVIEW
149
1889
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1879-80
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1884.
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VOL. XXXVIII.
JAN.-MARCH,
1887.
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JOHNS HOPKINS
Volume 2
The Papers of Thomas A. Edison
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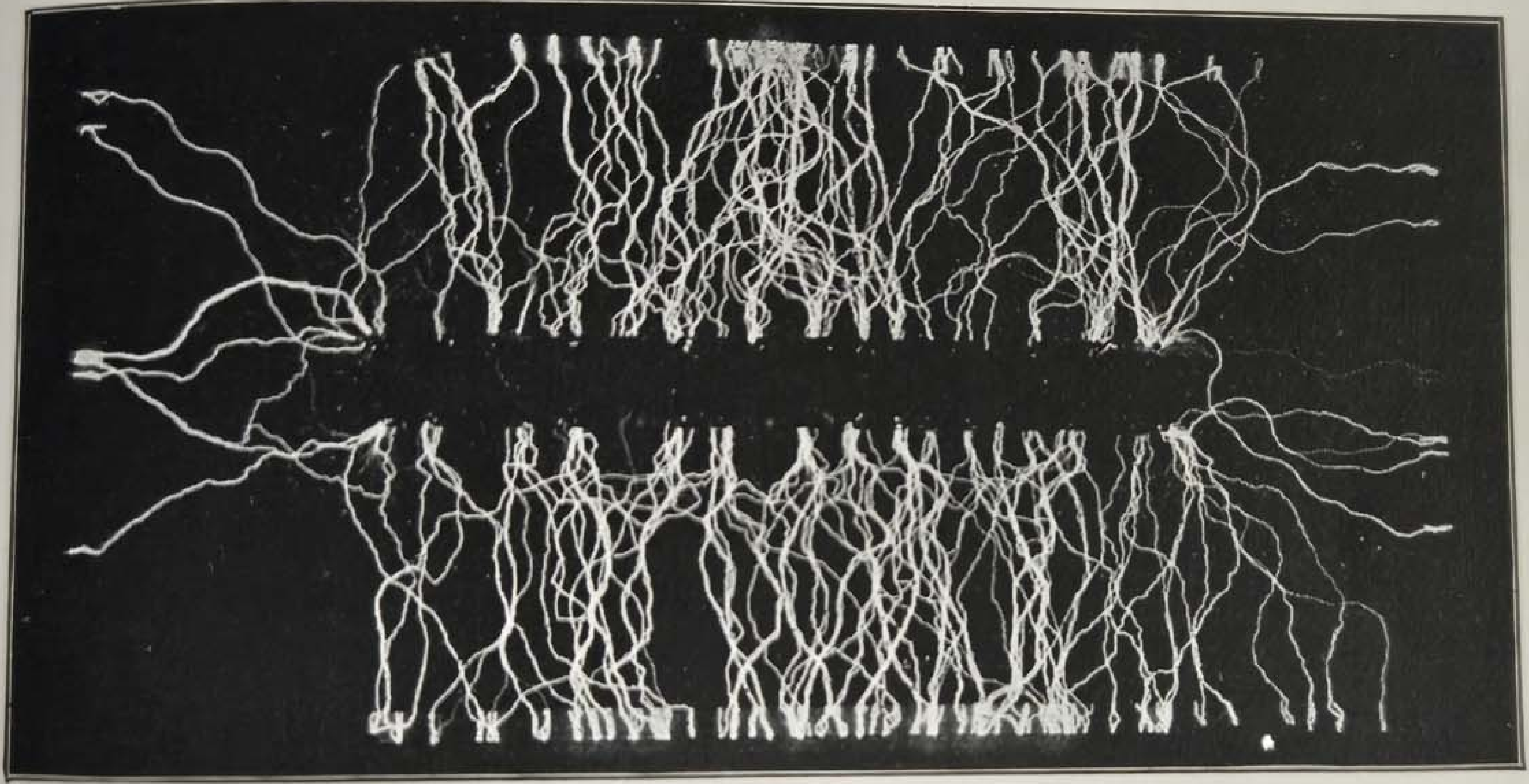
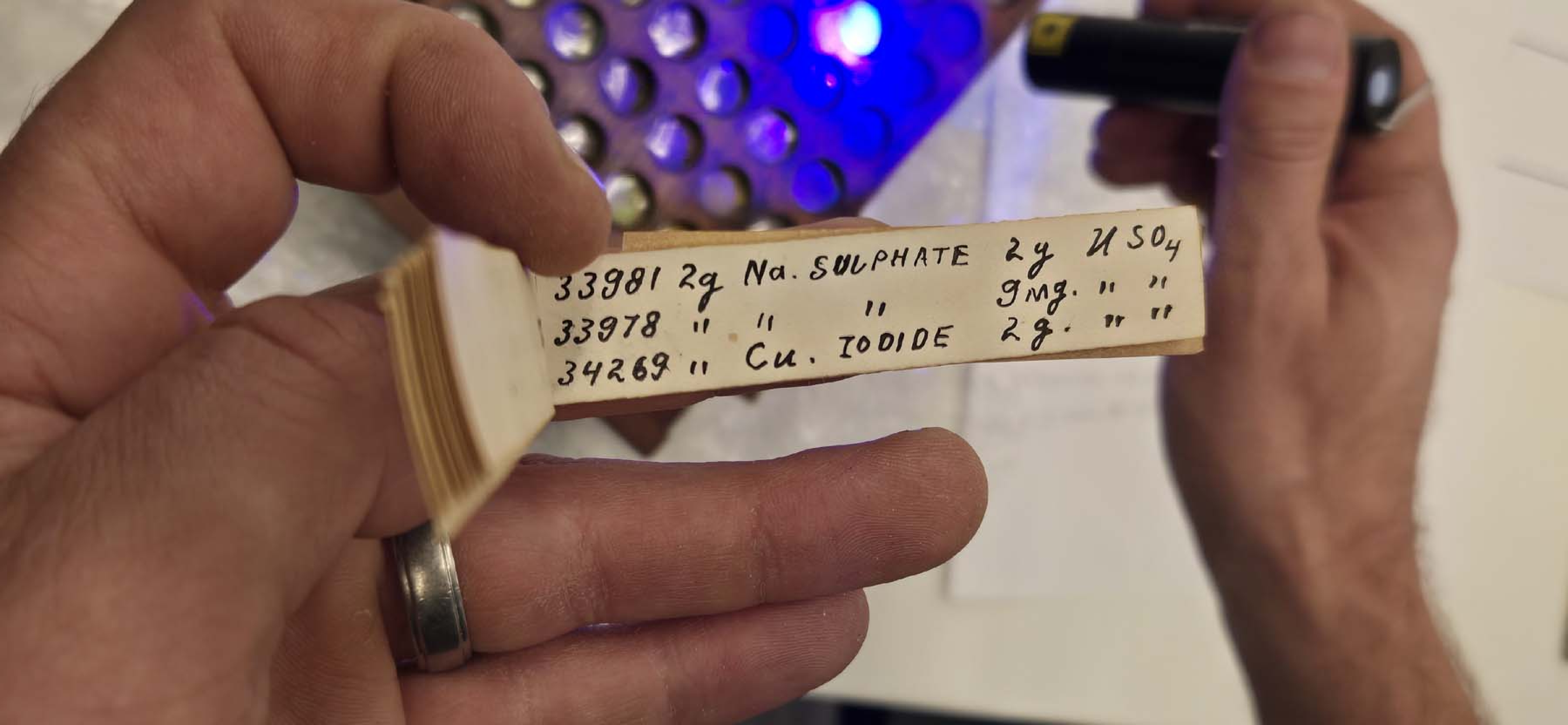
Volume 3
The Papers of Thomas A. Edison
MENLO PARK: THE EARLY YEARS
April 1876–December 1877
JOHNS HOPKINS
Volume 4
1878
JEHL

being connected to the letters by means of invisible wires, while the other terminal was connected to tin foil on the back of the glass plate.



High Potential Discharge.—Tesla.

When the current was turned on, the electricity was discharged from the



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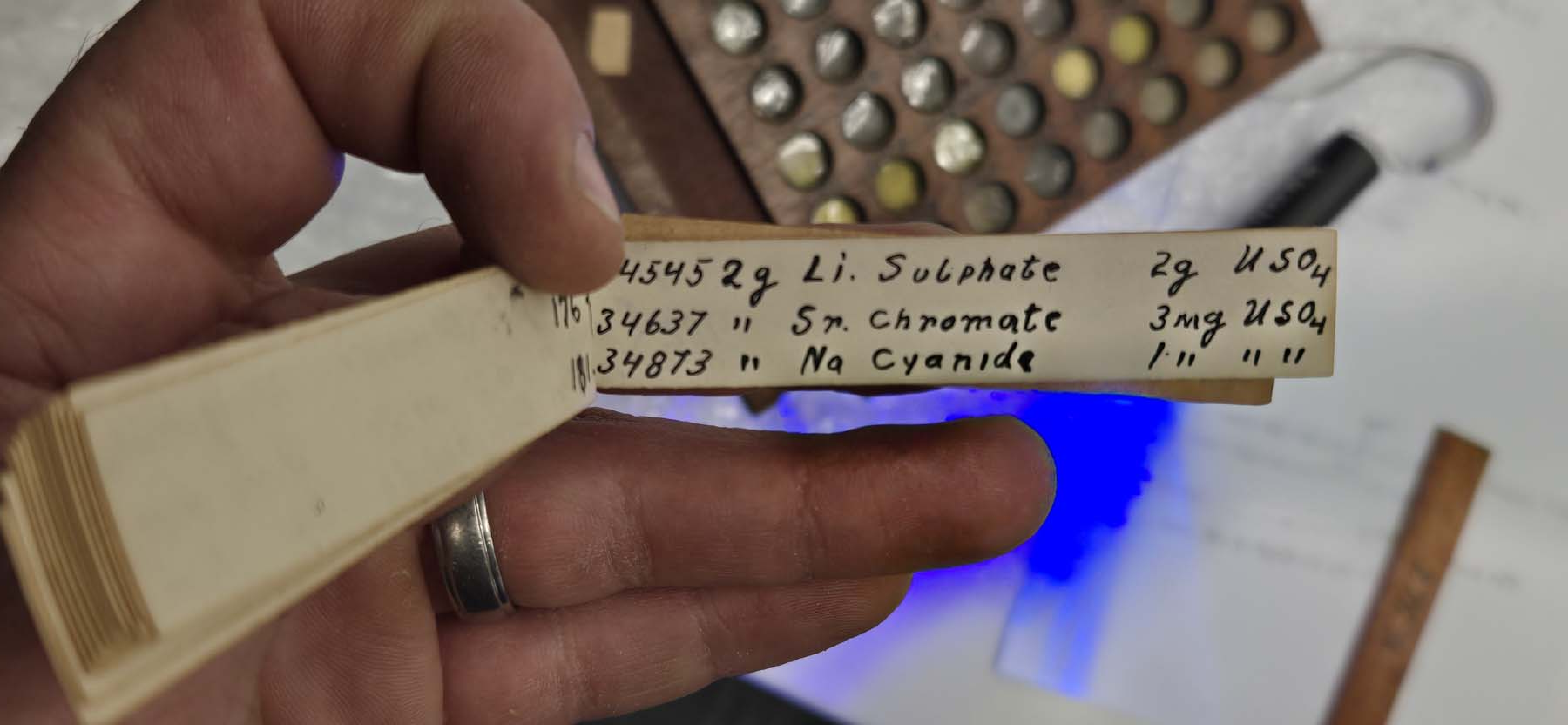
33978 " " " 9mg. " "
34269 " Cu. IODIDE 2g. " "



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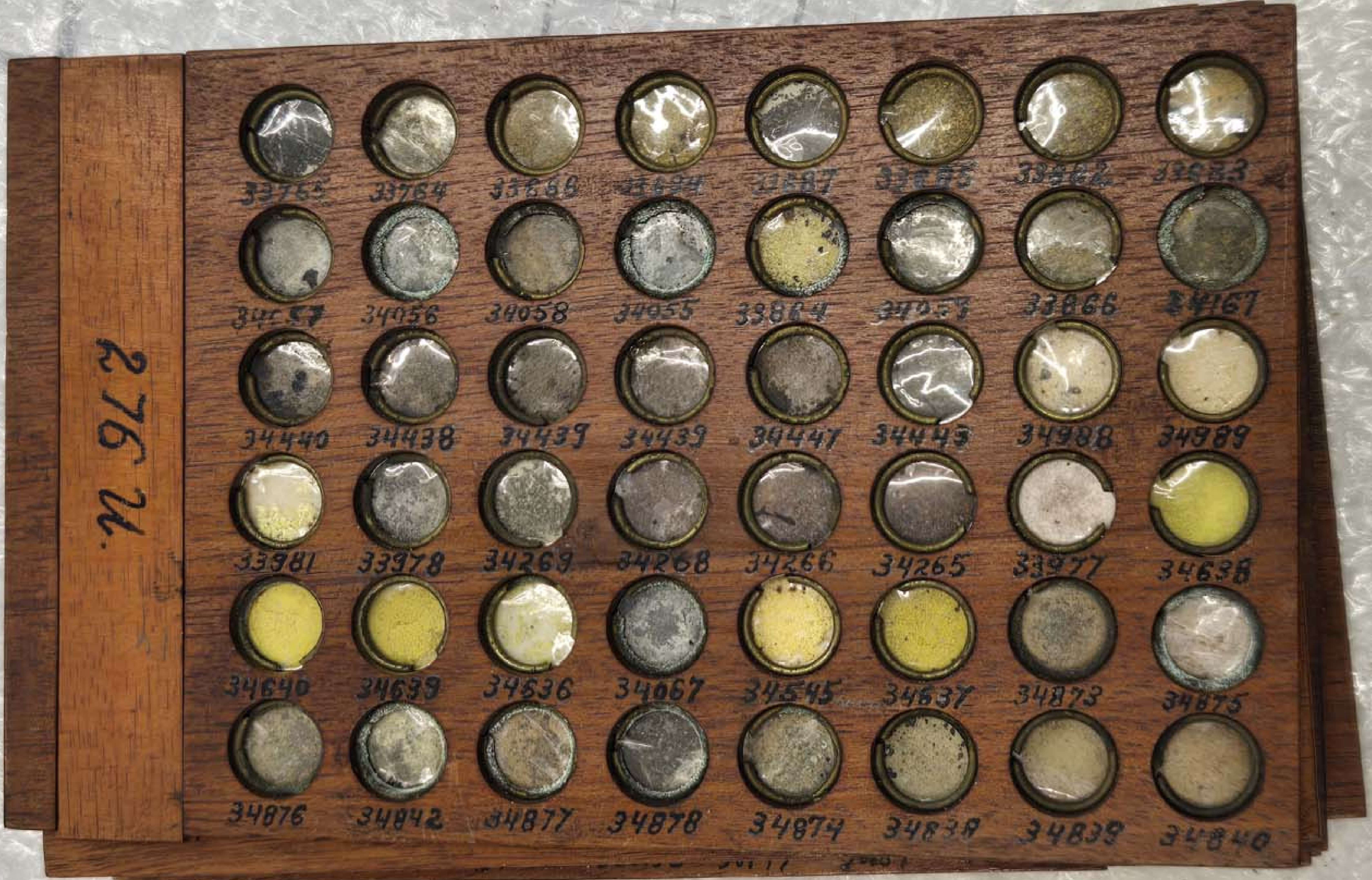
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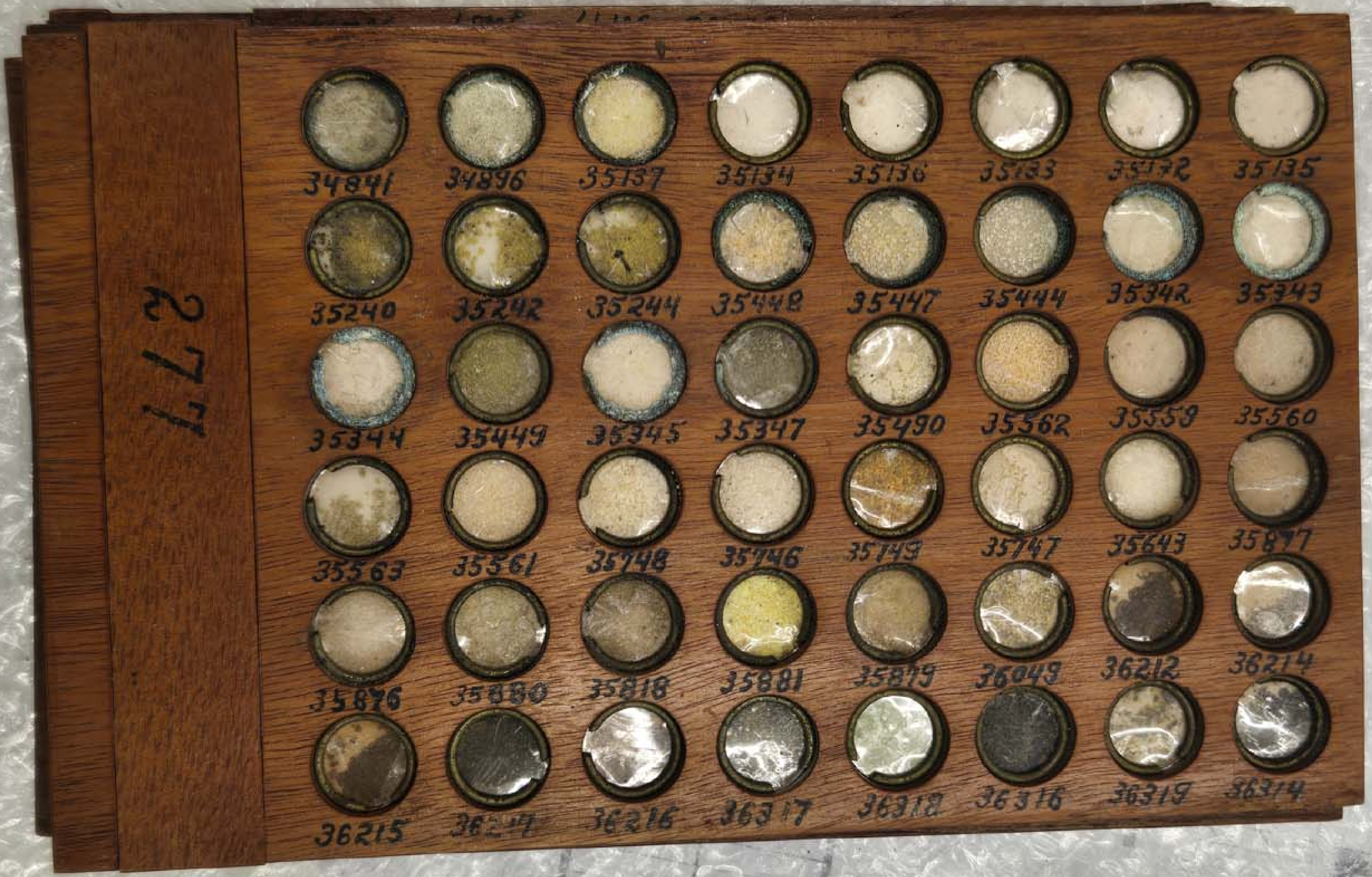
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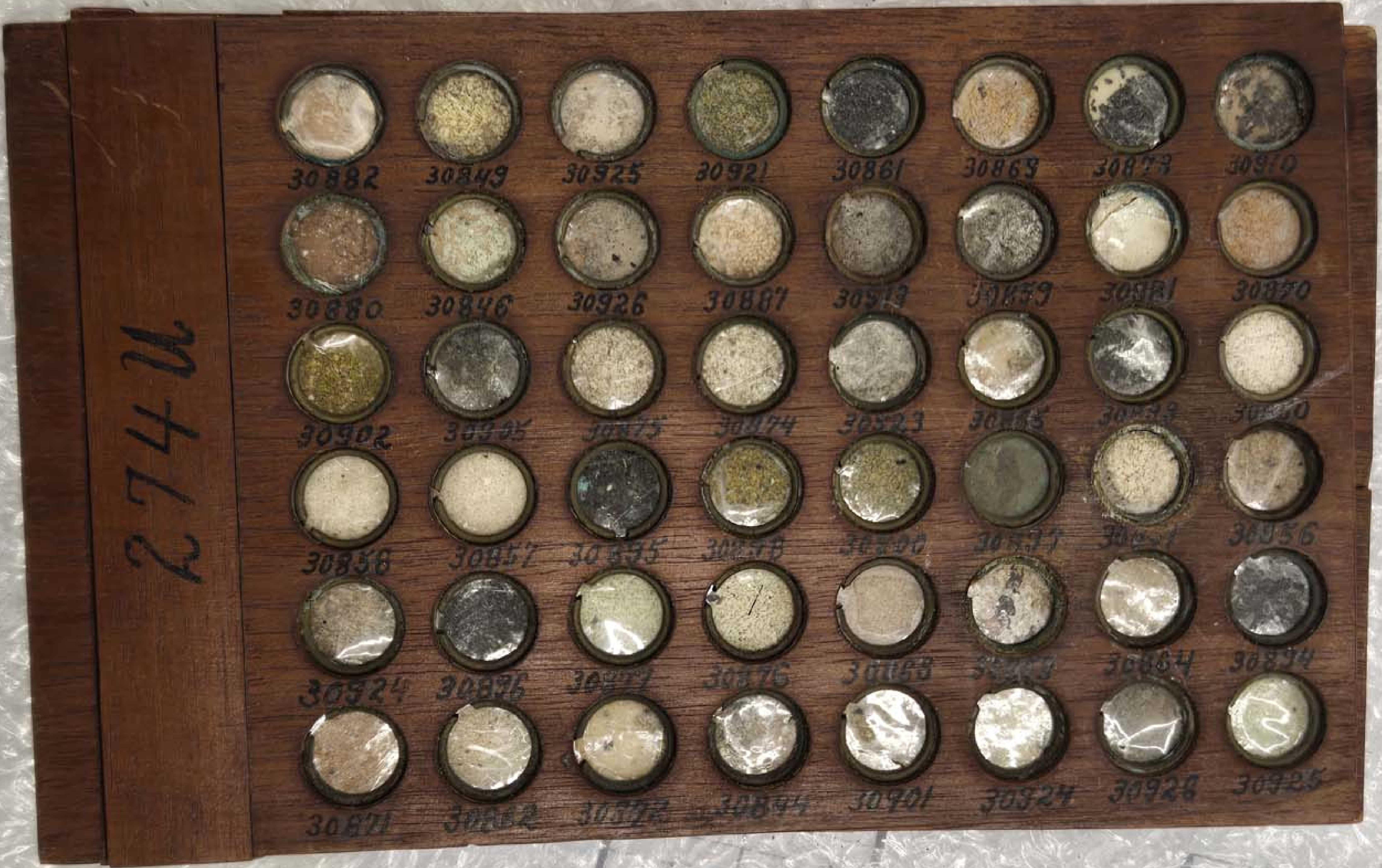
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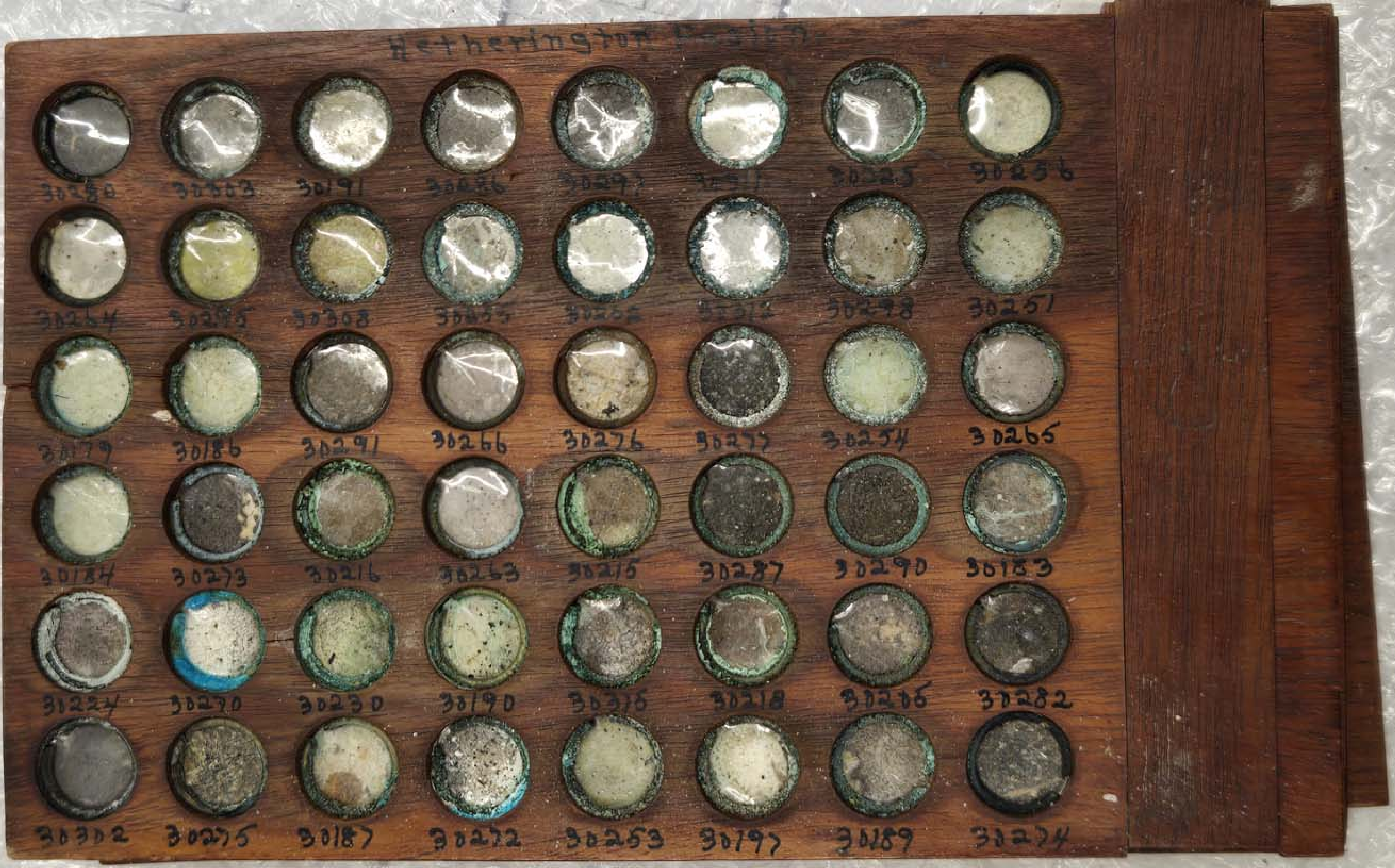Hetherington Design
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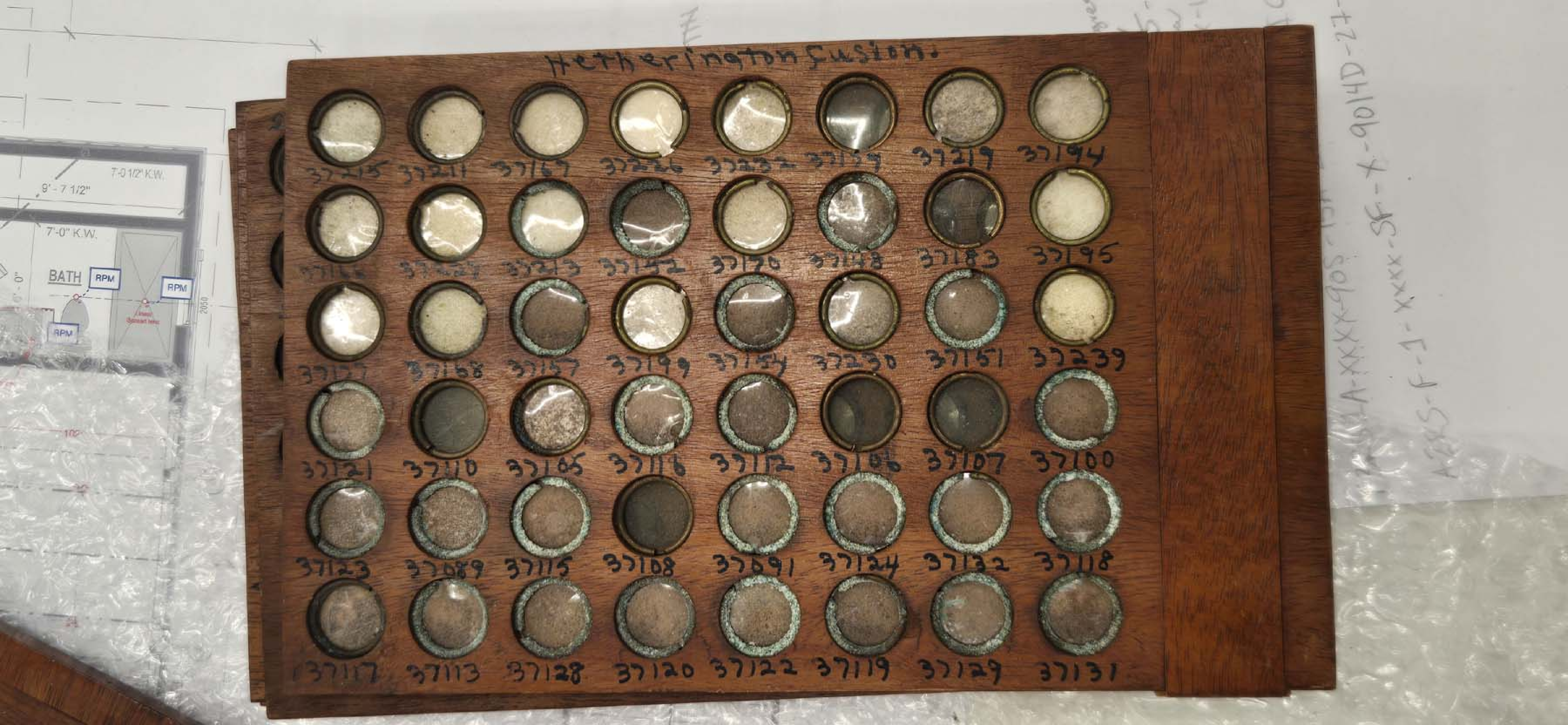
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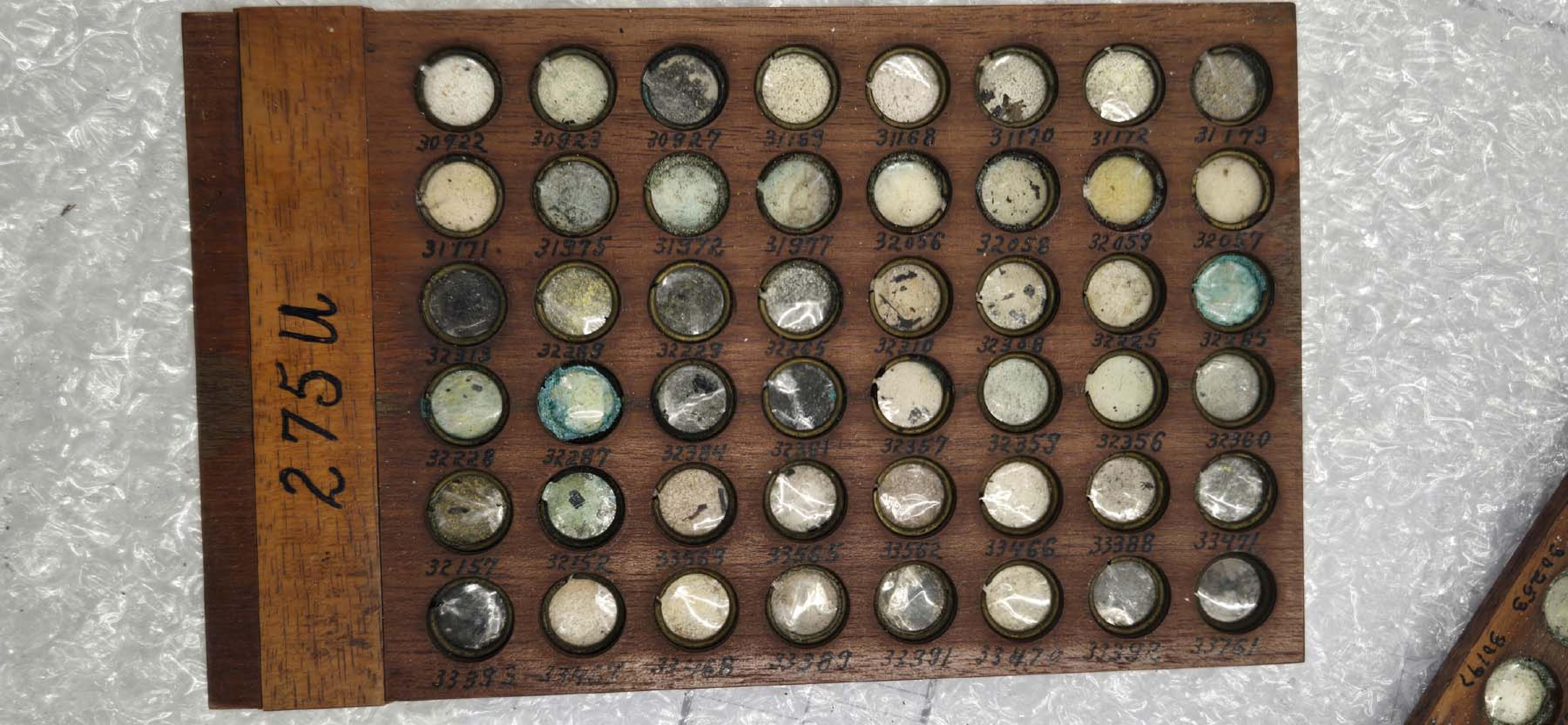
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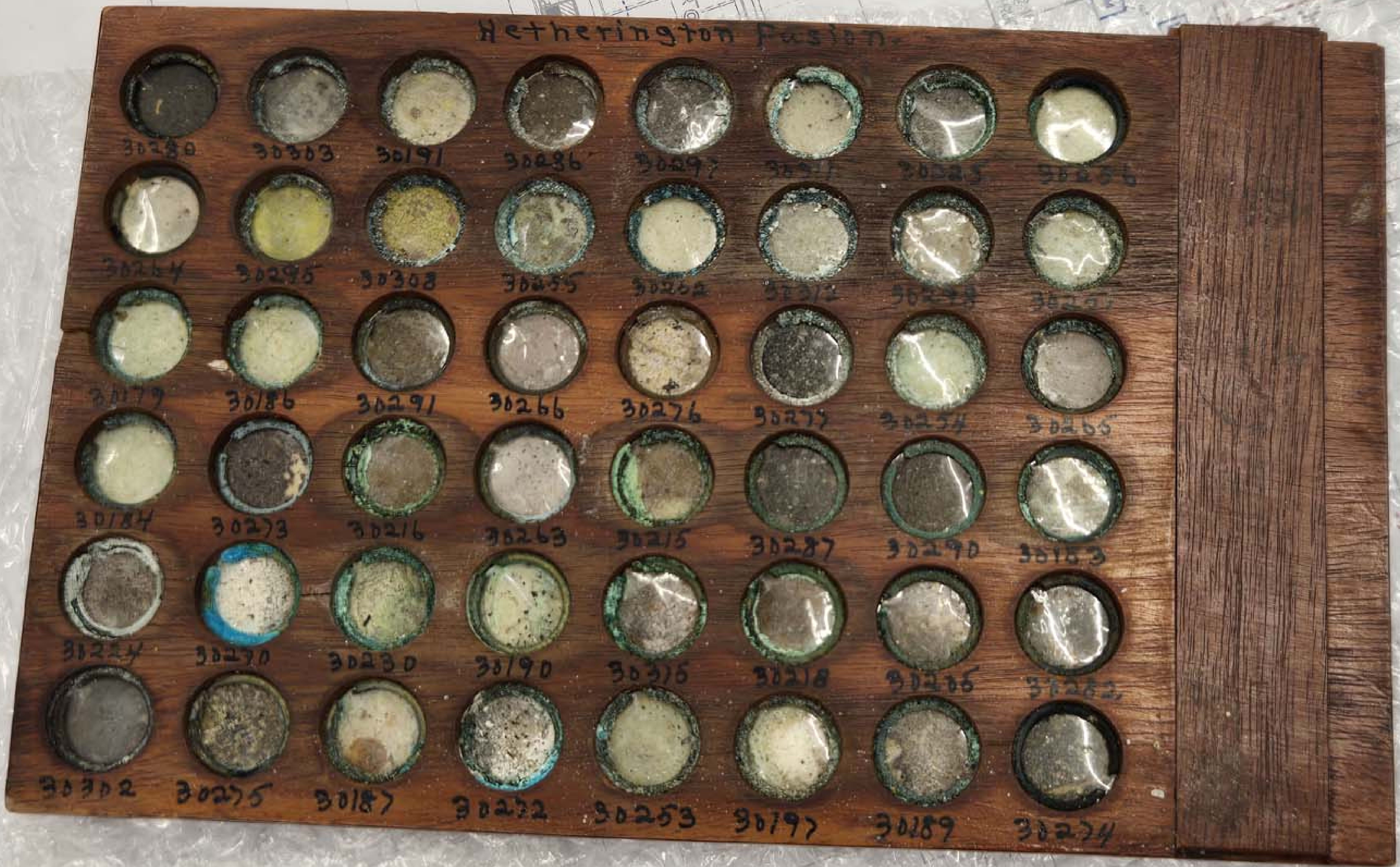
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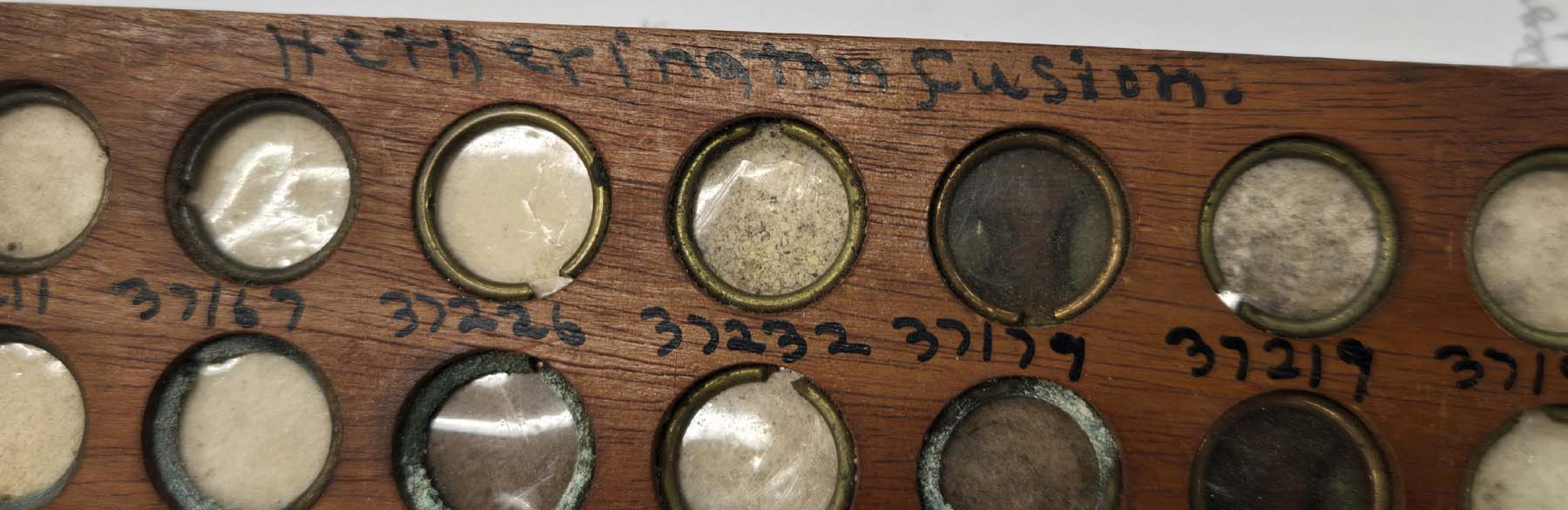

Hetherington fusion.
11
37167
37226
37232
37179
37219
371

32385
32360
33444
33392
33388
33356
33470
Hetherington Easton.
30191
30286
30297
30311
30325
30256

EDISON E. L. CO.
-VS-
WESTINGHOUSE, CHURCH,
KERR AND COMPANY
DIST OF NEW JERSEY
PATENT 274290
COMPLAINANT'S

WENDELL STREET,

CORNER
HAMILTON STREET

BOSTON.

[illegible]

GOT THE DROP

[illegible]

To facilitate the keeping of time, the following system will go into effect June 4, 1888:—

Each employe will be given a number by which he will be recognized on the time book. Checks, with corresponding numbers, will be found on check boards at entrances through Factories "A" and "C." When entering to commence work, the employe will remove the check corresponding to his number, and deposit same in box provided for the purpose.

In computing time, no credit will be given for less than thirty minutes.

No employe will be allowed to commence work who is more than 10 minutes late.

Any employe desiring to leave the factory during working hours must obtain a pass from the Foreman of his or her department and deposit it in the box at entrance.

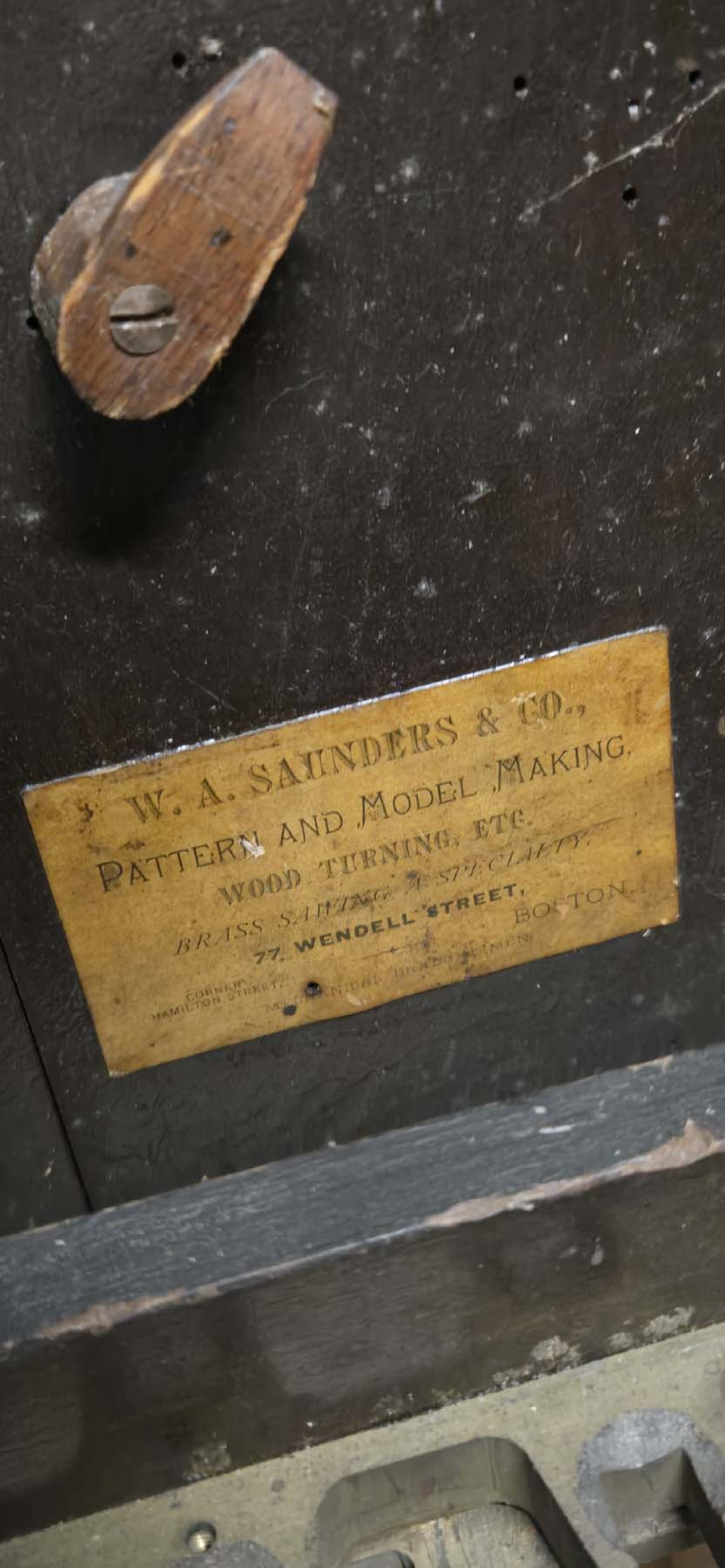
Commencing Monday, June 4th, White Cards will be discontinued. Yellow and Pink Cards will be required as usual, and employes are requested to write their numbers in space provided for them on cards.

You will enter through Factory A entrance. Your number

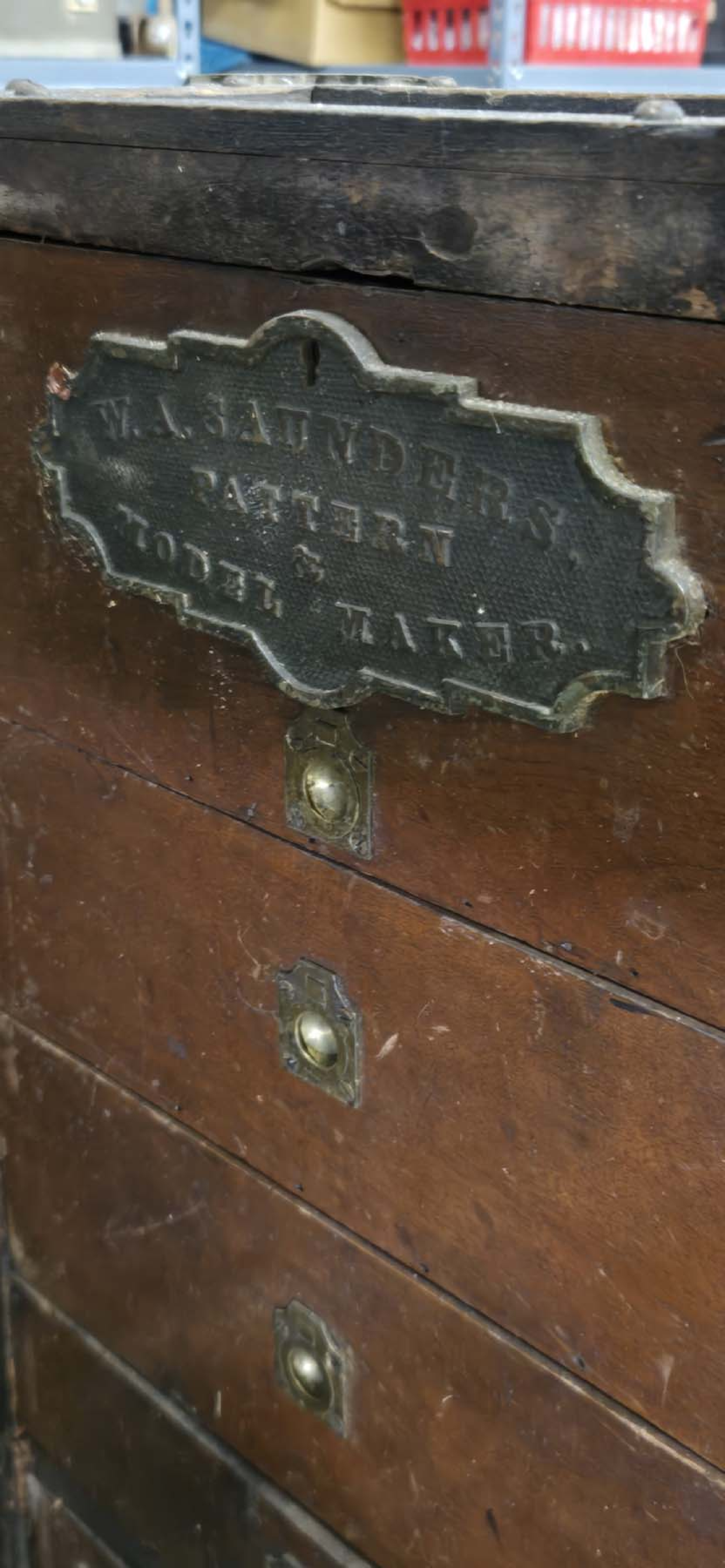
393

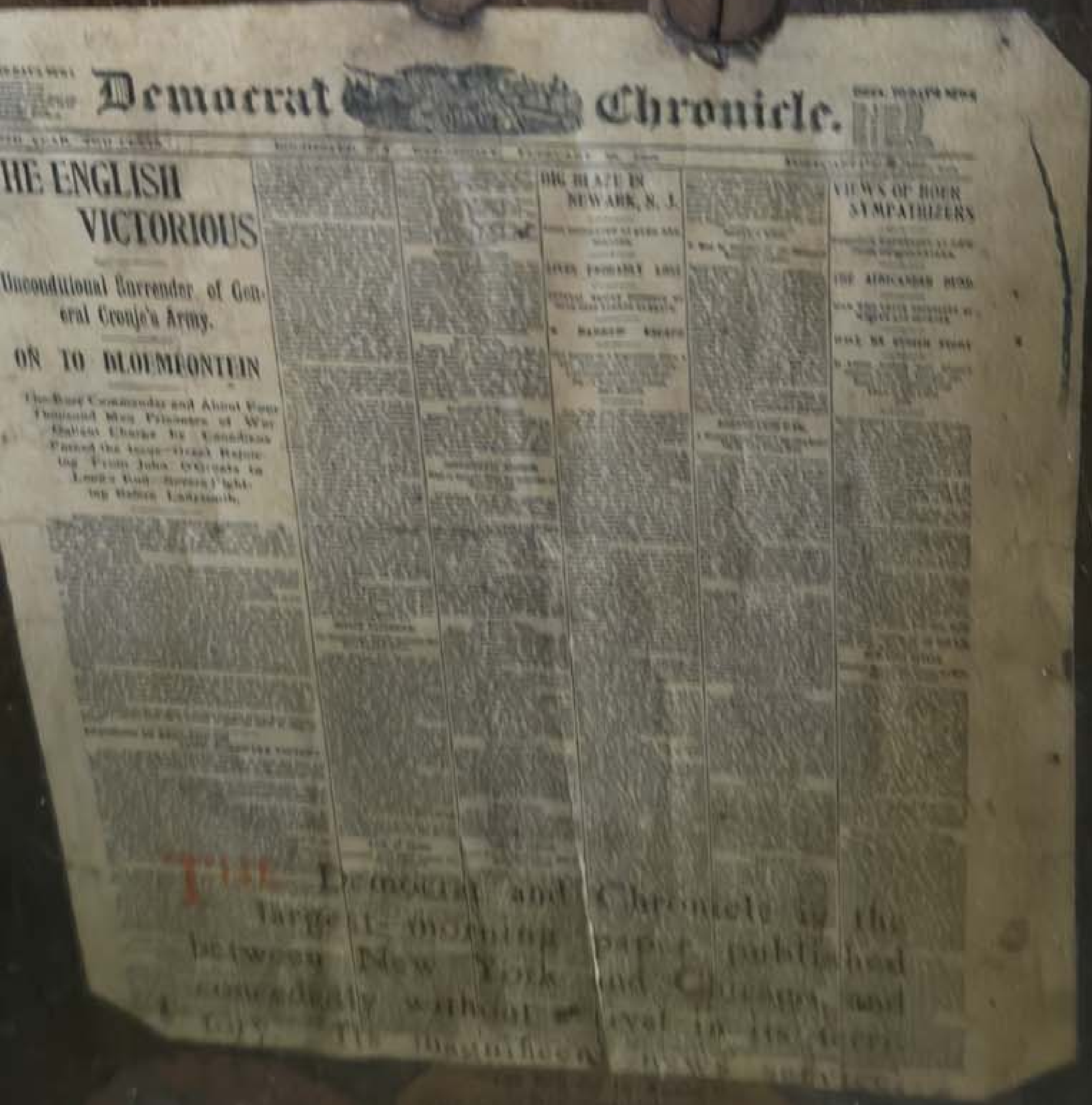
THOMSON-HOUSTON ELECTRIC CO.
E. W. Rice, Jr., Supt.

Lynn, Mass., June 4, 1888.



W. A. SAUNDERS & CO.,
PATTERN AND MODEL MAKING,
WOOD TURNING, ETC.
BRASS SAWING A SPECIALTY.
77. WENDELL STREET,
BOSTON.
CORNER
HAMILTON STREET.
[illegible]


W. A. SAUNDERS,
PATTERN
&
MODEL MAKER.



Democrat and Chronicle.

HE ENGLISH VICTORIOUS

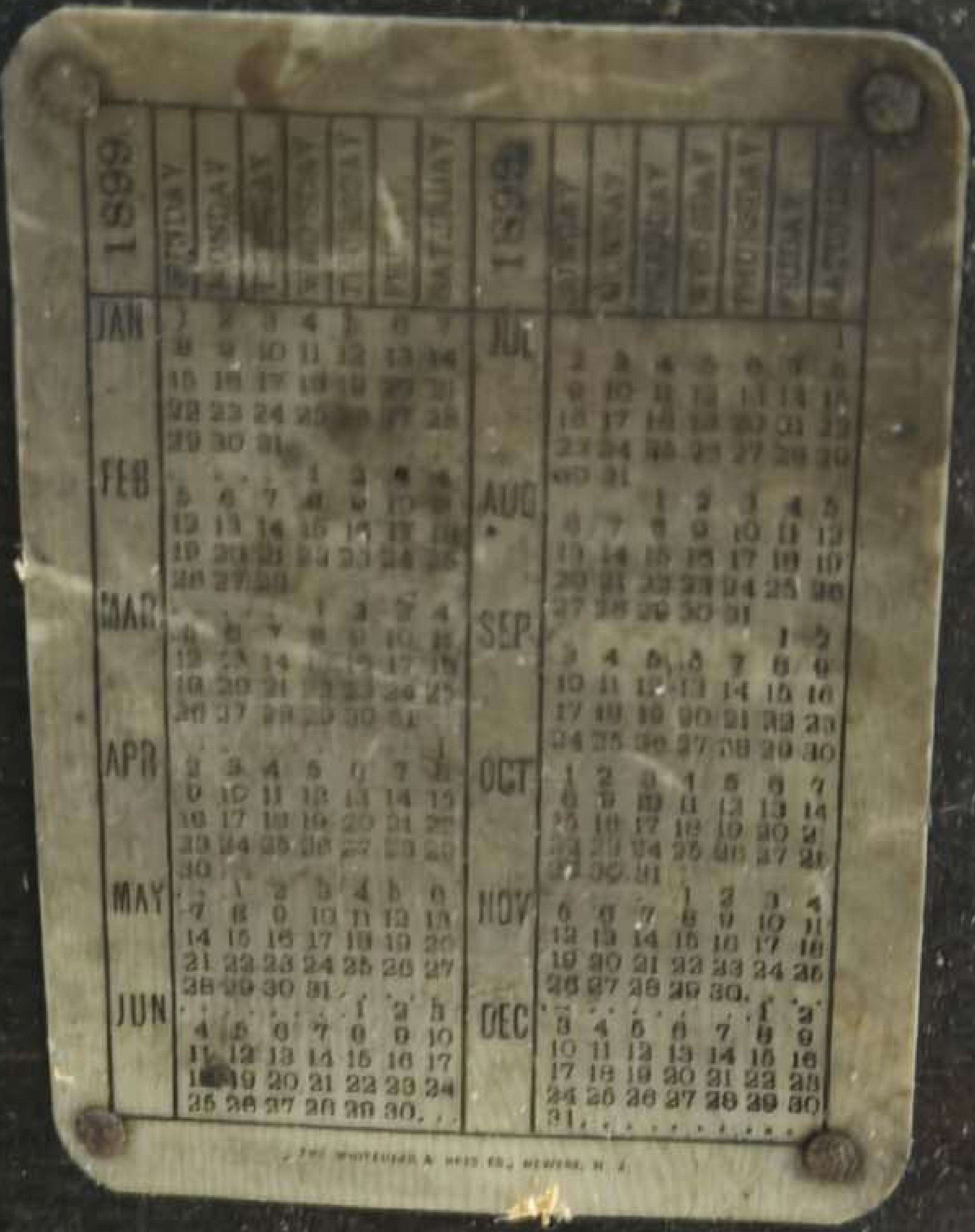
Unconditional Surrender of General Cronje's Army.

ON TO BLOEMFONTEIN

BIG BLAZE IN NEWARK, N. J.

VIEWS OF BOER SYMPATHIZERS

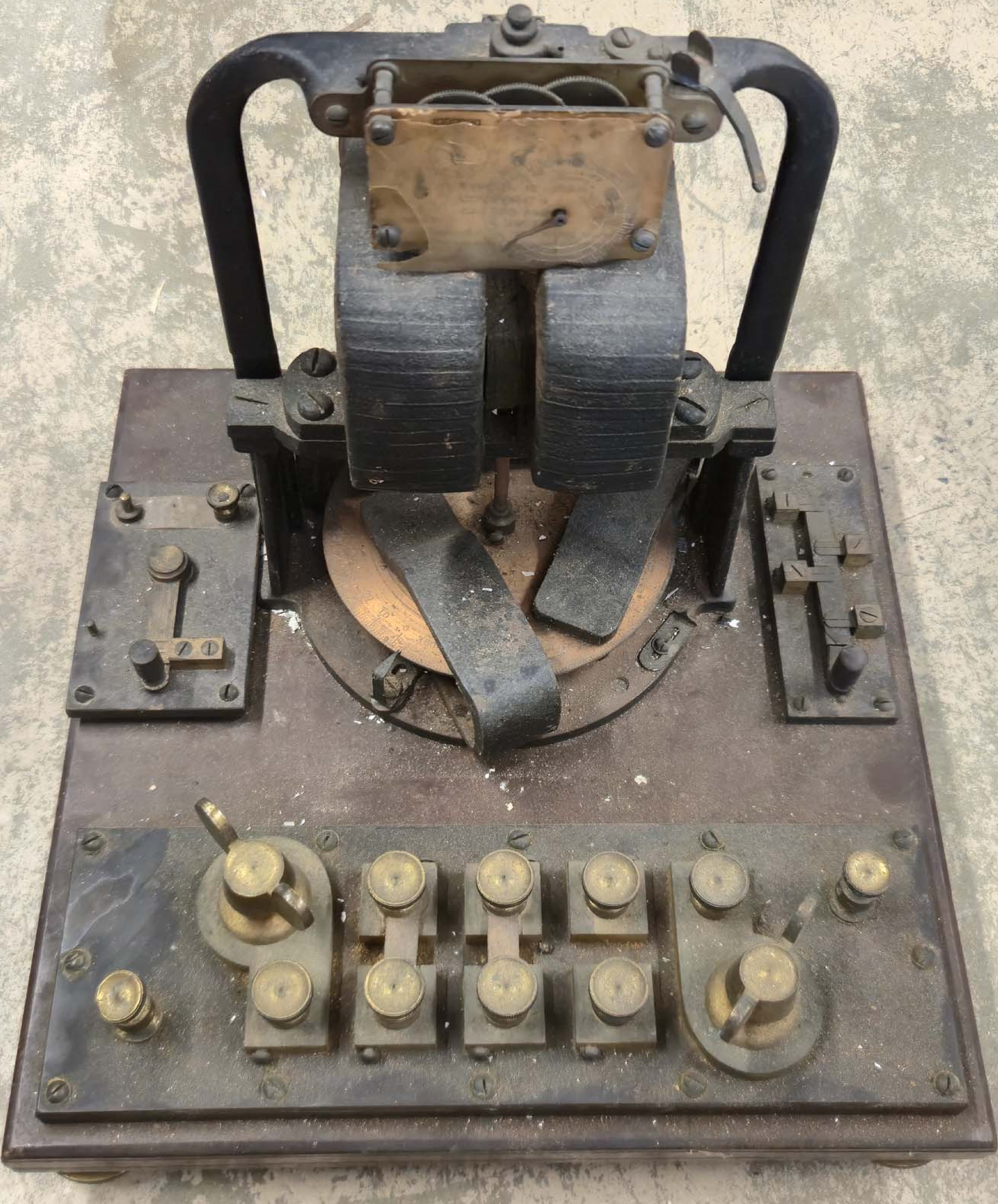
THE Democrat and Chronicle is the largest morning paper published between New York and Chicago, and [illegible] without a rival in its [illegible]

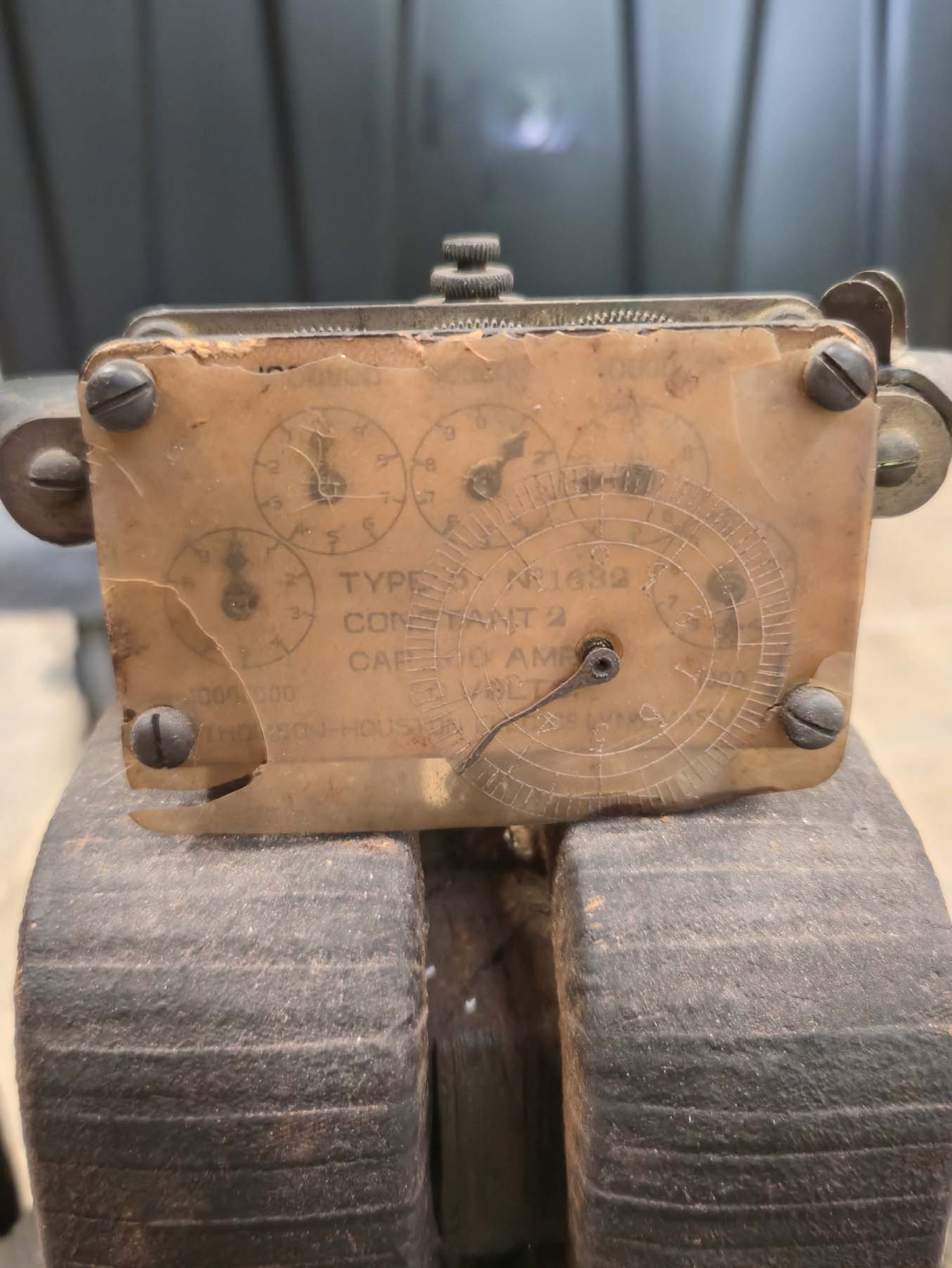


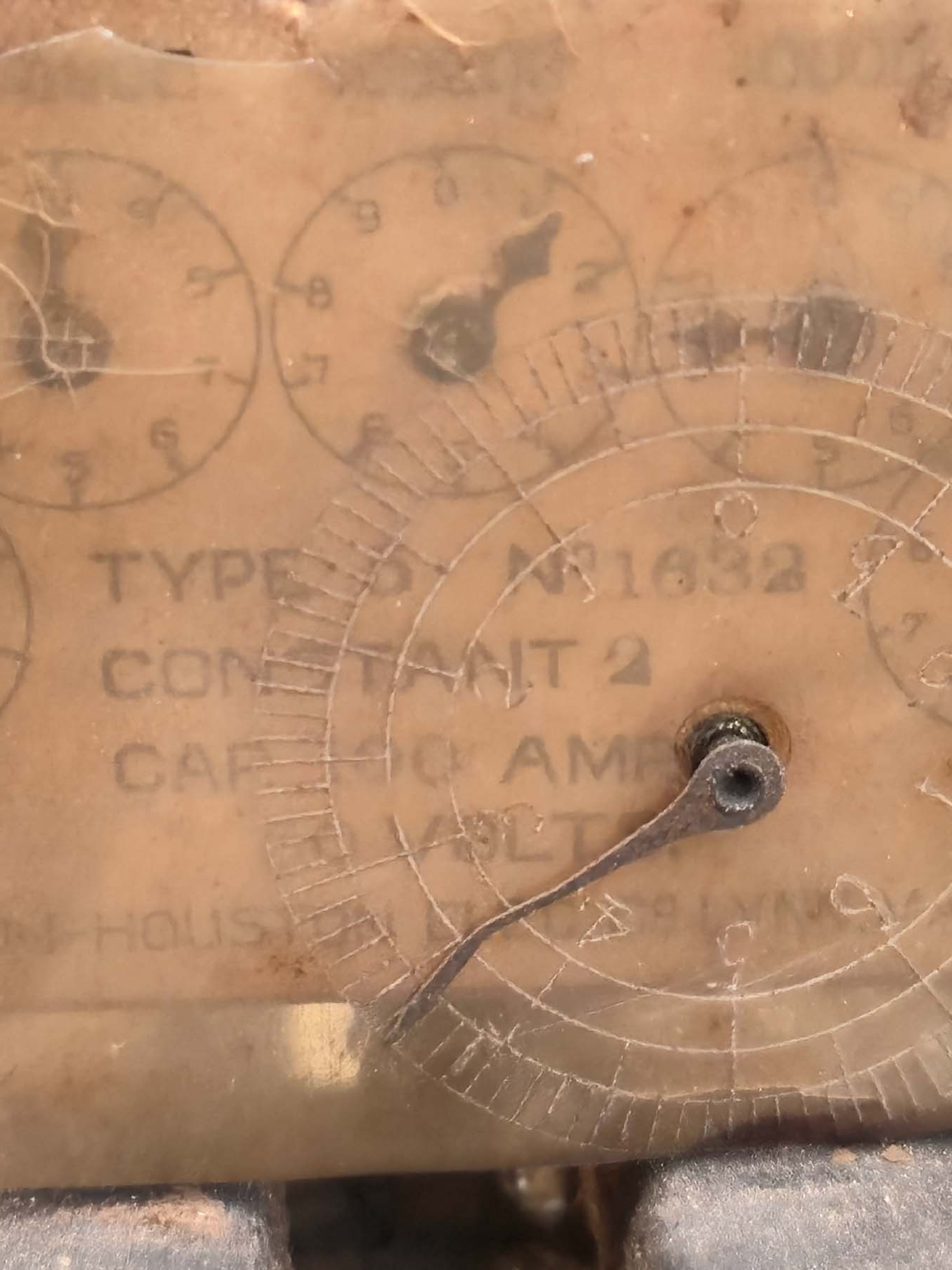
1899	SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
JAN	1	2	3	4	5	6	7
	8	9	10	11	12	13	14
	15	16	17	18	19	20	21
	22	23	24	25	26	27	28
	29	30	31				
FEB				1	2	3	4
	5	6	7	8	9	10	11
	12	13	14	15	16	17	18
	19	20	21	22	23	24	25
	26	27	28				
MAR				1	2	3	4
	5	6	7	8	9	10	11
	12	13	14	15	16	17	18
	19	20	21	22	23	24	25
	26	27	28	29	30	31	
APR							1
	2	3	4	5	6	7	8
	9	10	11	12	13	14	15
	16	17	18	19	20	21	22
	23	24	25	26	27	28	29
	30						
MAY		1	2	3	4	5	6
	7	8	9	10	11	12	13
	14	15	16	17	18	19	20
	21	22	23	24	25	26	27
	28	29	30	31			
JUN					1	2	3
	4	5	6	7	8	9	10
	11	12	13	14	15	16	17
	18	19	20	21	22	23	24
	25	26	27	28	29	30	

1899	SUNDAY	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY	SATURDAY
JUL							1
	2	3	4	5	6	7	8
	9	10	11	12	13	14	15
	16	17	18	19	20	21	22
	23	24	25	26	27	28	29
	30	31					
AUG			1	2	3	4	5
	6	7	8	9	10	11	12
	13	14	15	16	17	18	19
	20	21	22	23	24	25	26
	27	28	29	30	31		
SEP						1	2
	3	4	5	6	7	8	9
	10	11	12	13	14	15	16
	17	18	19	20	21	22	23
	24	25	26	27	28	29	30
OCT	1	2	3	4	5	6	7
	8	9	10	11	12	13	14
	15	16	17	18	19	20	21
	22	23	24	25	26	27	28
	29	30	31				
NOV				1	2	3	4
	5	6	7	8	9	10	11
	12	13	14	15	16	17	18
	19	20	21	22	23	24	25
	26	27	28	29	30		
DEC						1	2
	3	4	5	6	7	8	9
	10	11	12	13	14	15	16
	17	18	19	20	21	22	23
	24	25	26	27	28	29	30
	31						

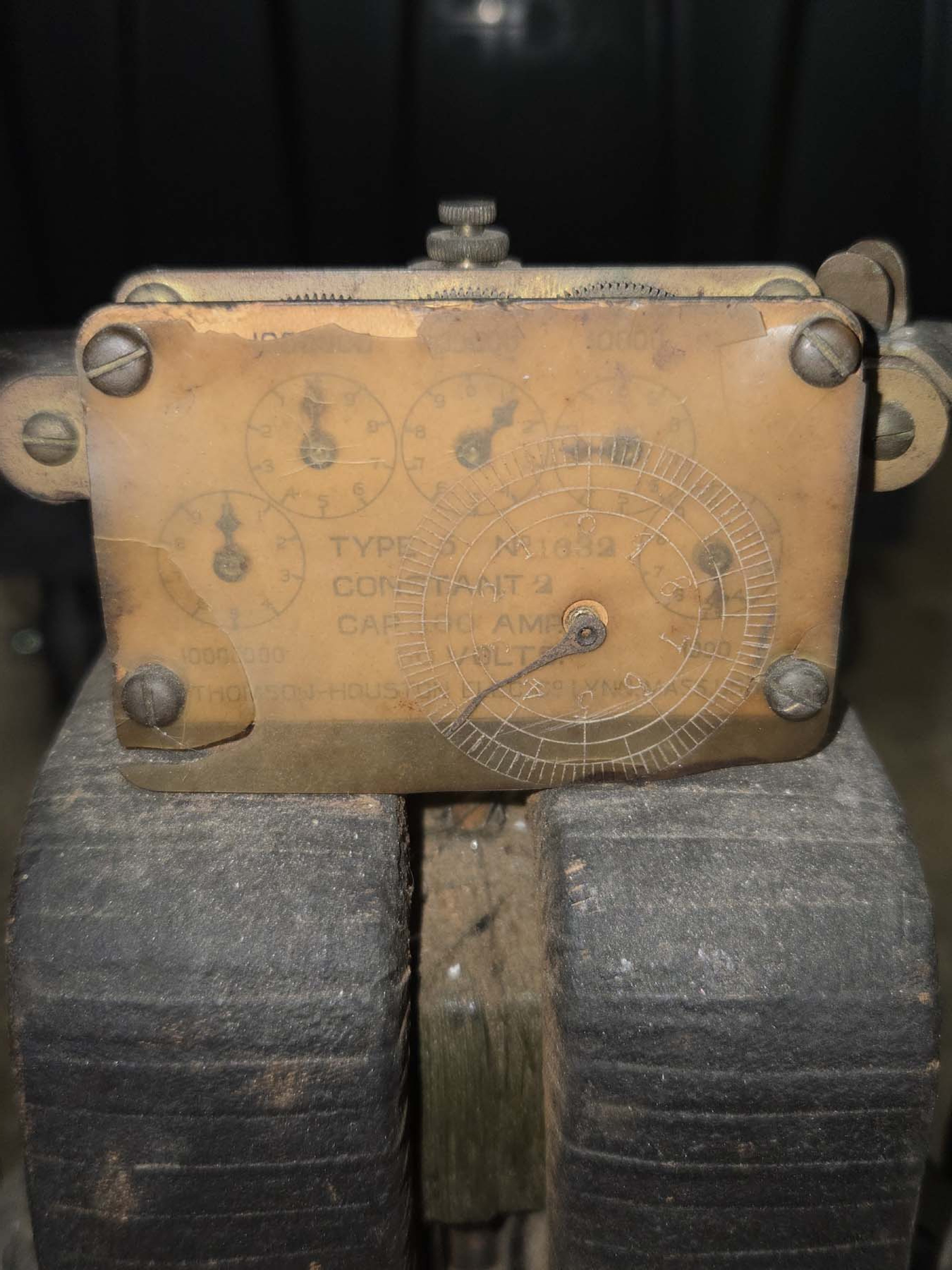
THE WHITEHEAD & HOAG CO., NEWARK, N. J.

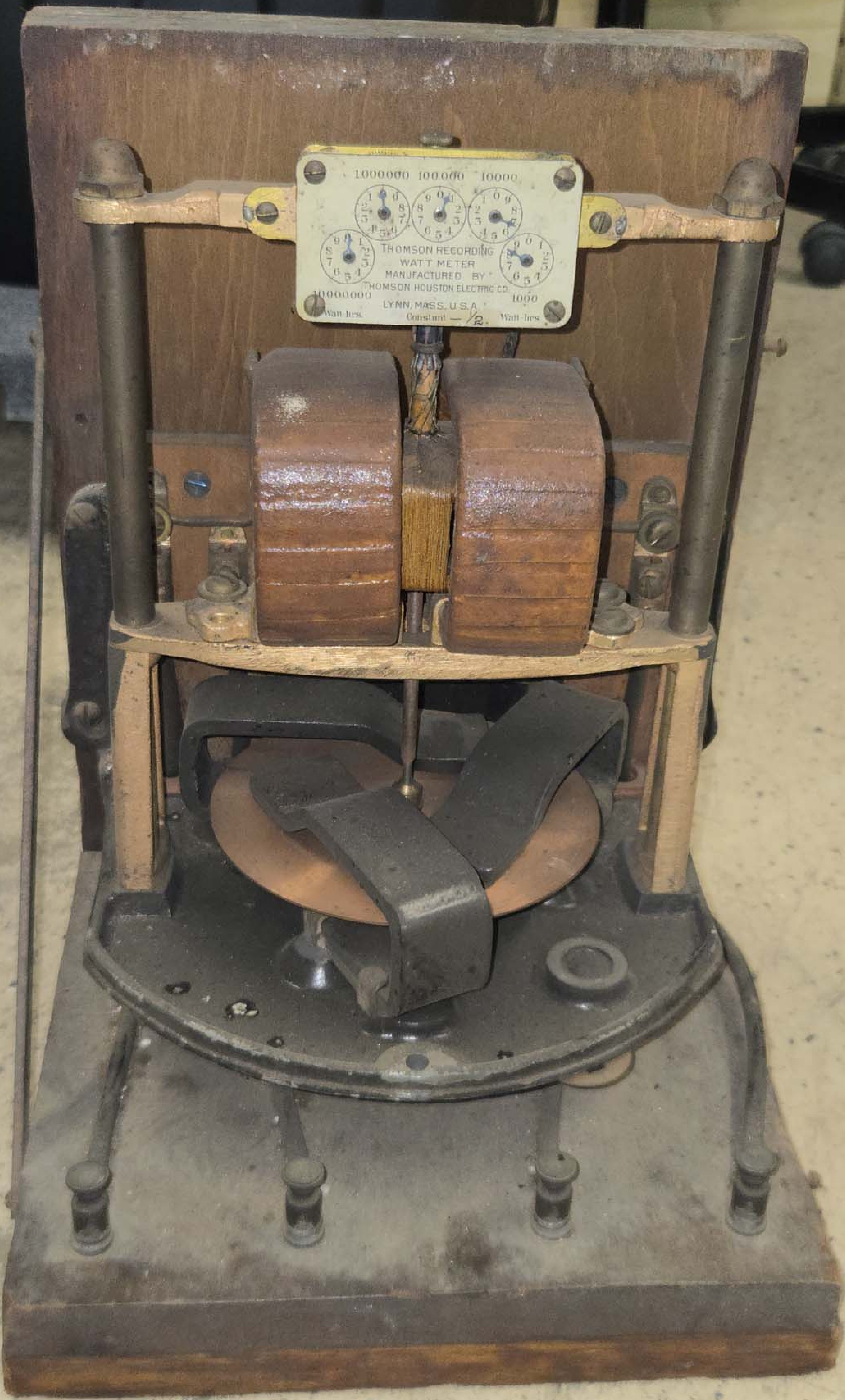


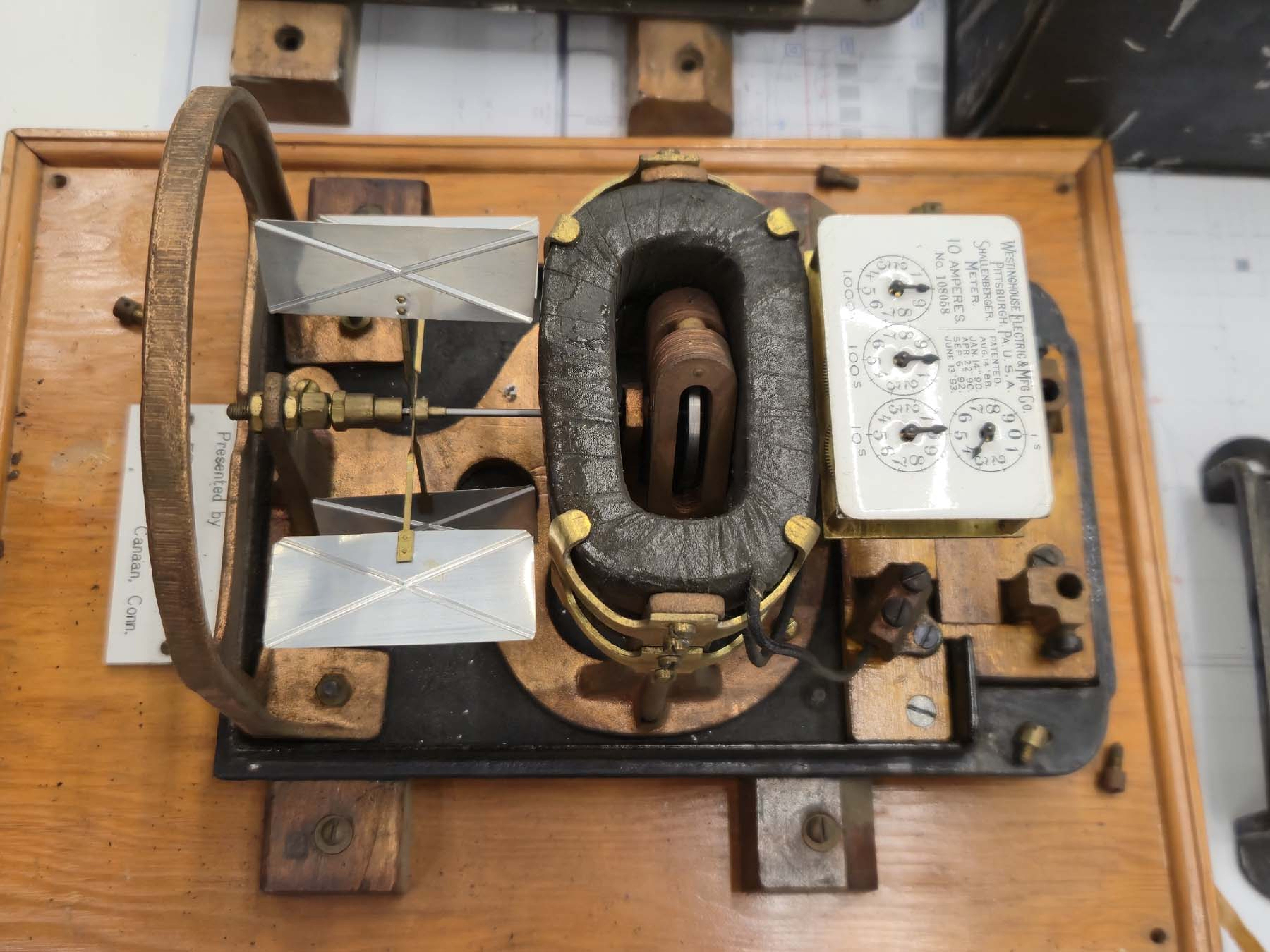

TYPE
Nº1632
CONSTANT 2
CAP
AMP
VOLT
1000000
THOMSON-HOUSTON
LYNN MASS

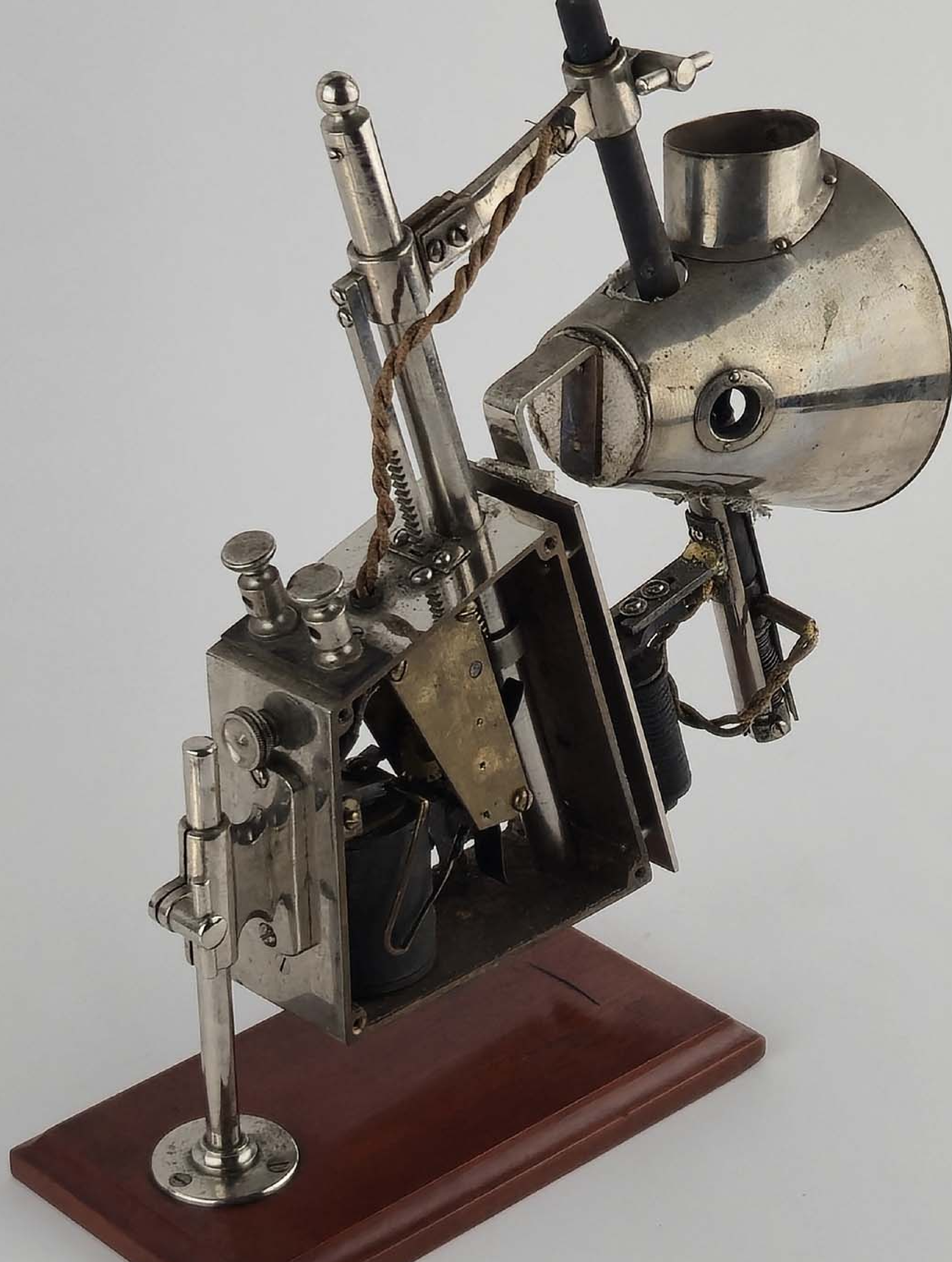


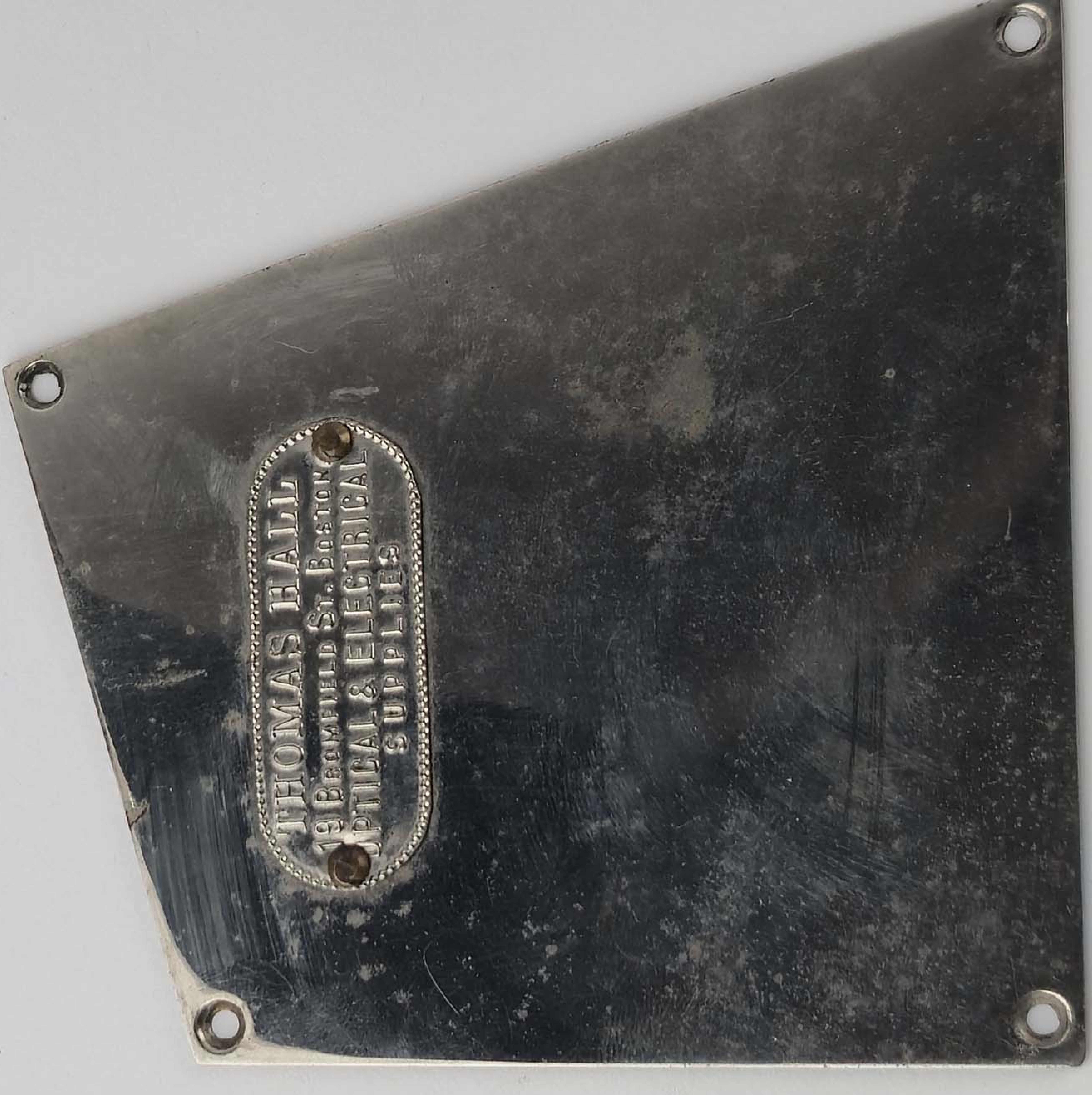
TYPE D
Nº1632
CONSTANT 2
CAP 100 AMP
VOLTS
HOUSTON
LYNN

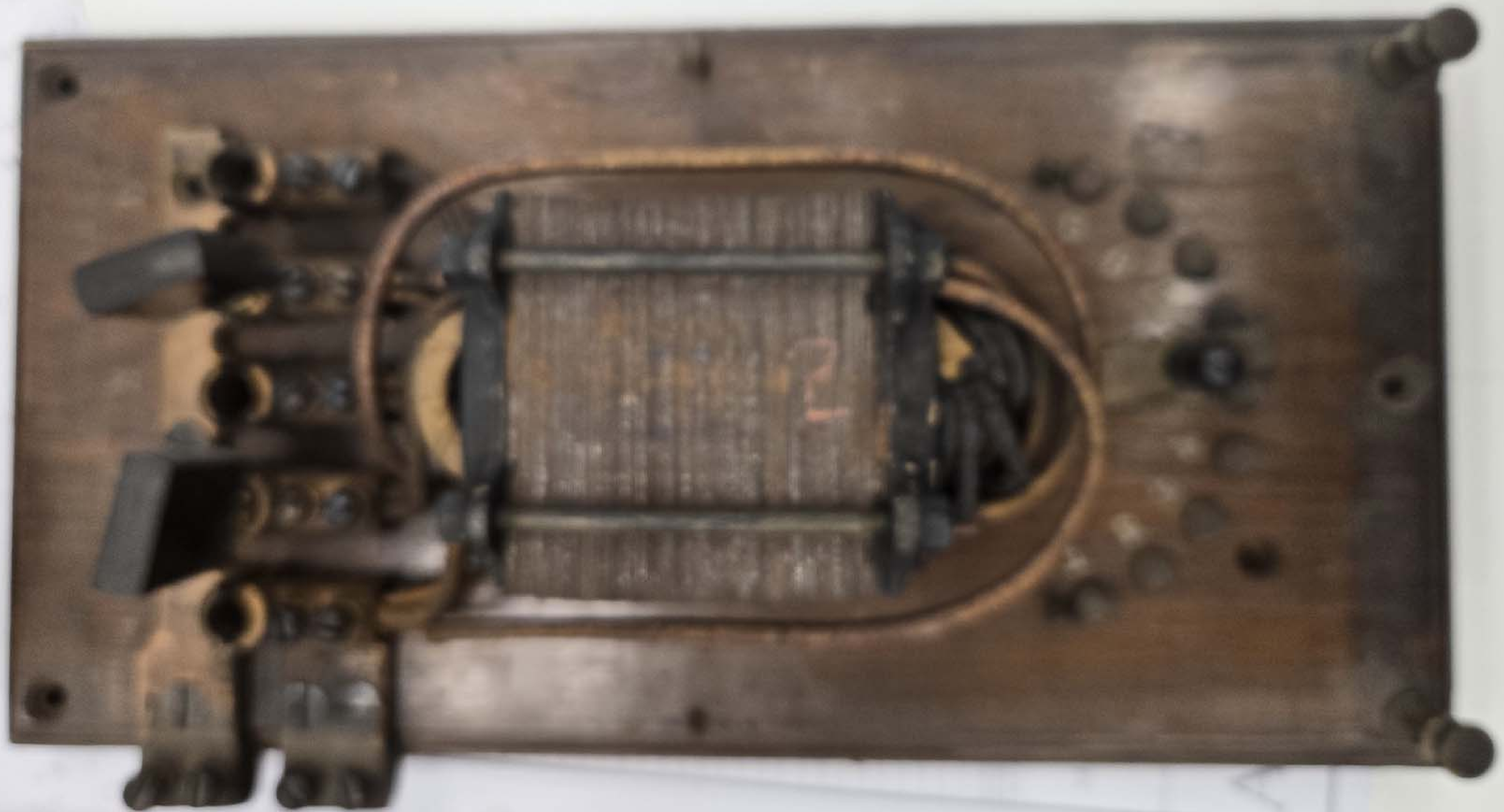

10000
TYPE D No 1632
CONSTANT 2
CAP. AMP
VOLTS
1000000
1000
THOMSON-HOUSTON ELEC Co LYNN MASS


1000000
100000
10000
THOMSON RECORDING
WATT METER
MANUFACTURED BY
THOMSON HOUSTON ELECTRIC CO.
10000000
1000
LYNN, MASS. U.S.A.
Watt-hrs.
Constant — 1/2
Watt-hrs.


WESTINGHOUSE ELECTRIC & MFG. CO.
PITTSBURGH, PA. U. S. A.
SHALLENBERGER.
METER.
10 AMPERES.
No. 108058
PATENTED.
AUG. 14. '88.
JAN. 14. '90.
APR. 22. '90.
SEP. 6. '92.
JUNE 13. '93.
1000s
100s
10s
1s
Presented by
Canaan, Conn.




THOMAS HALL
19 BROMFIELD ST. BOSTON
OPTICAL & ELECTRICAL
SUPPLIES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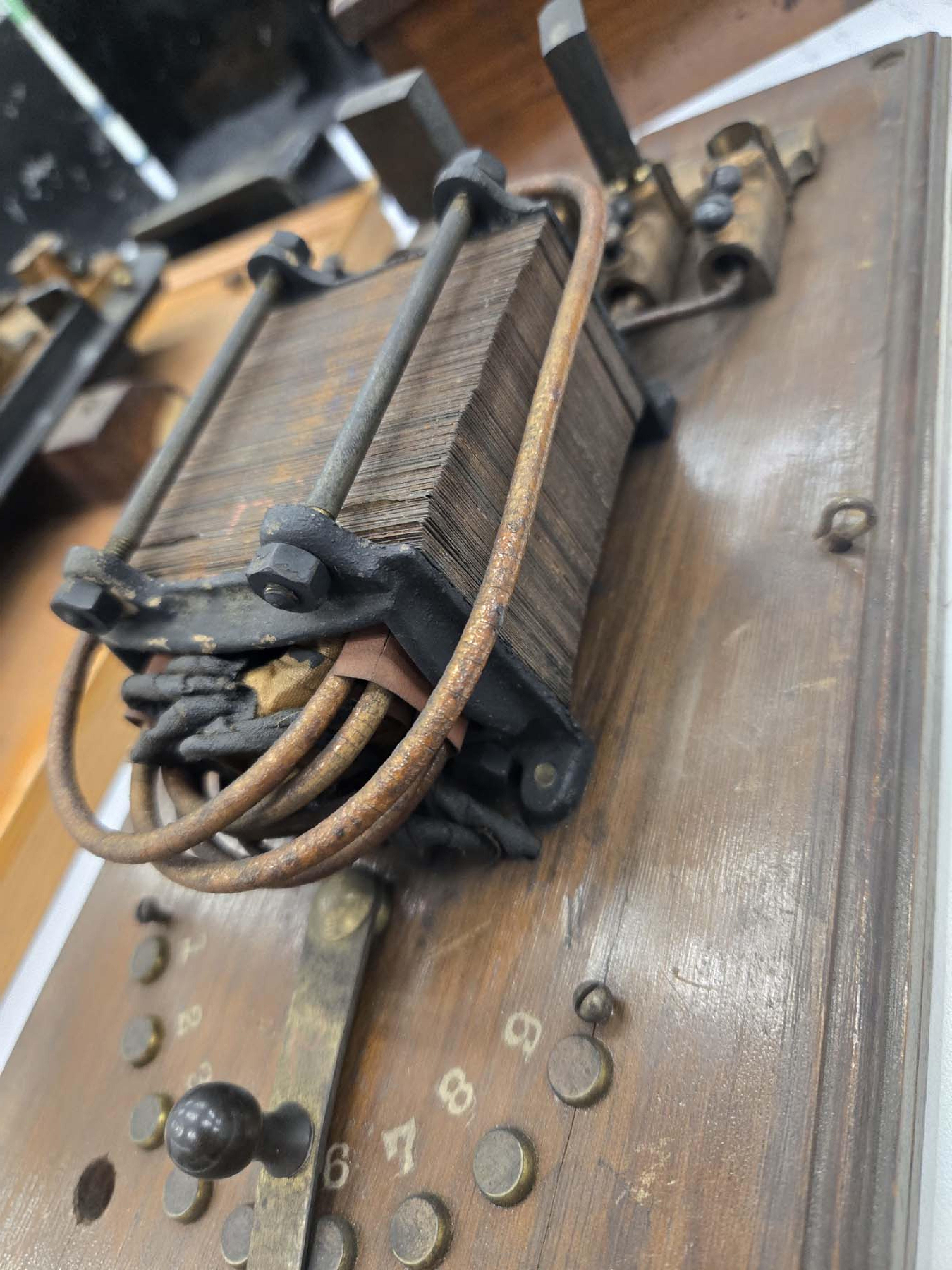
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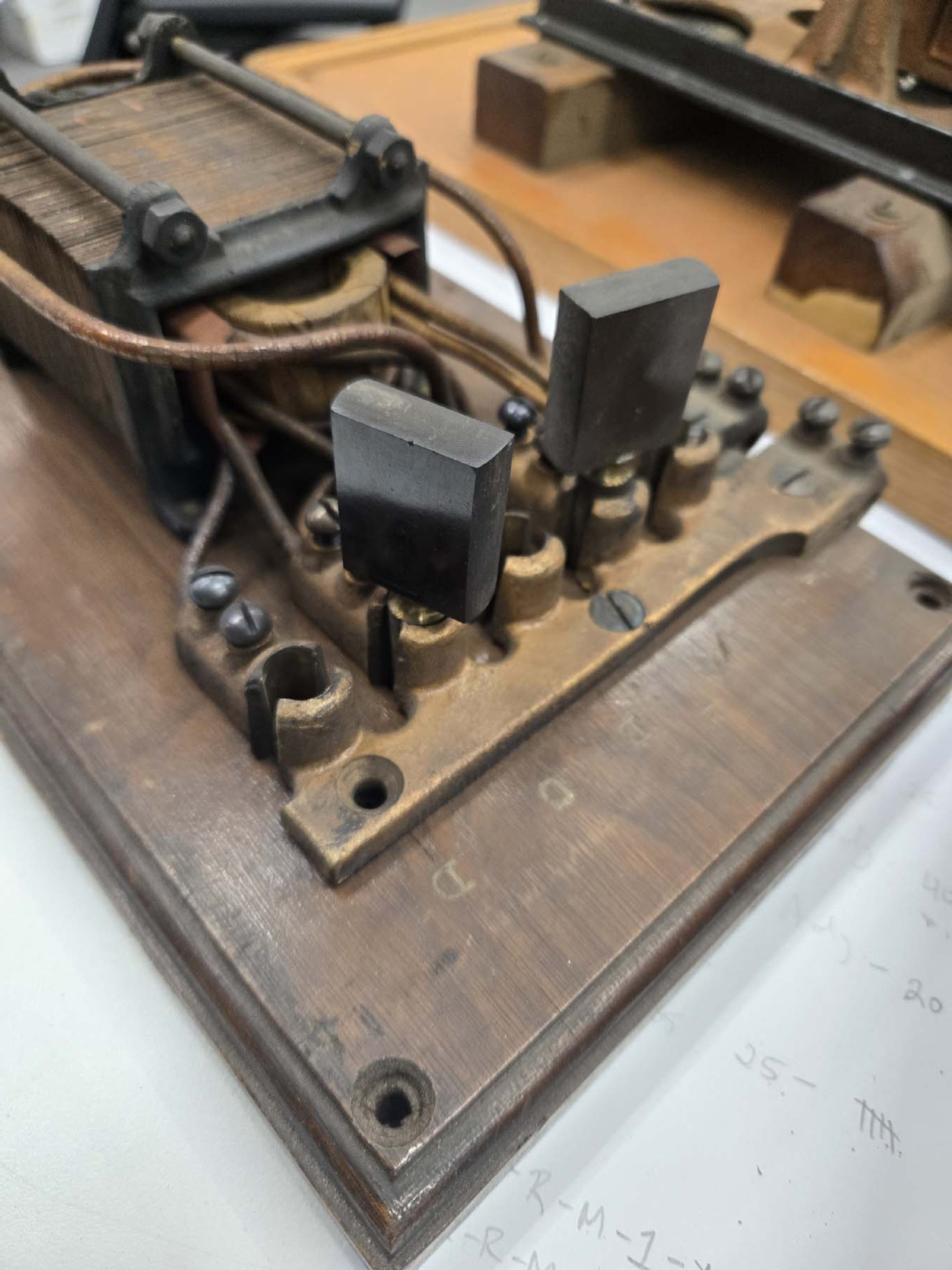

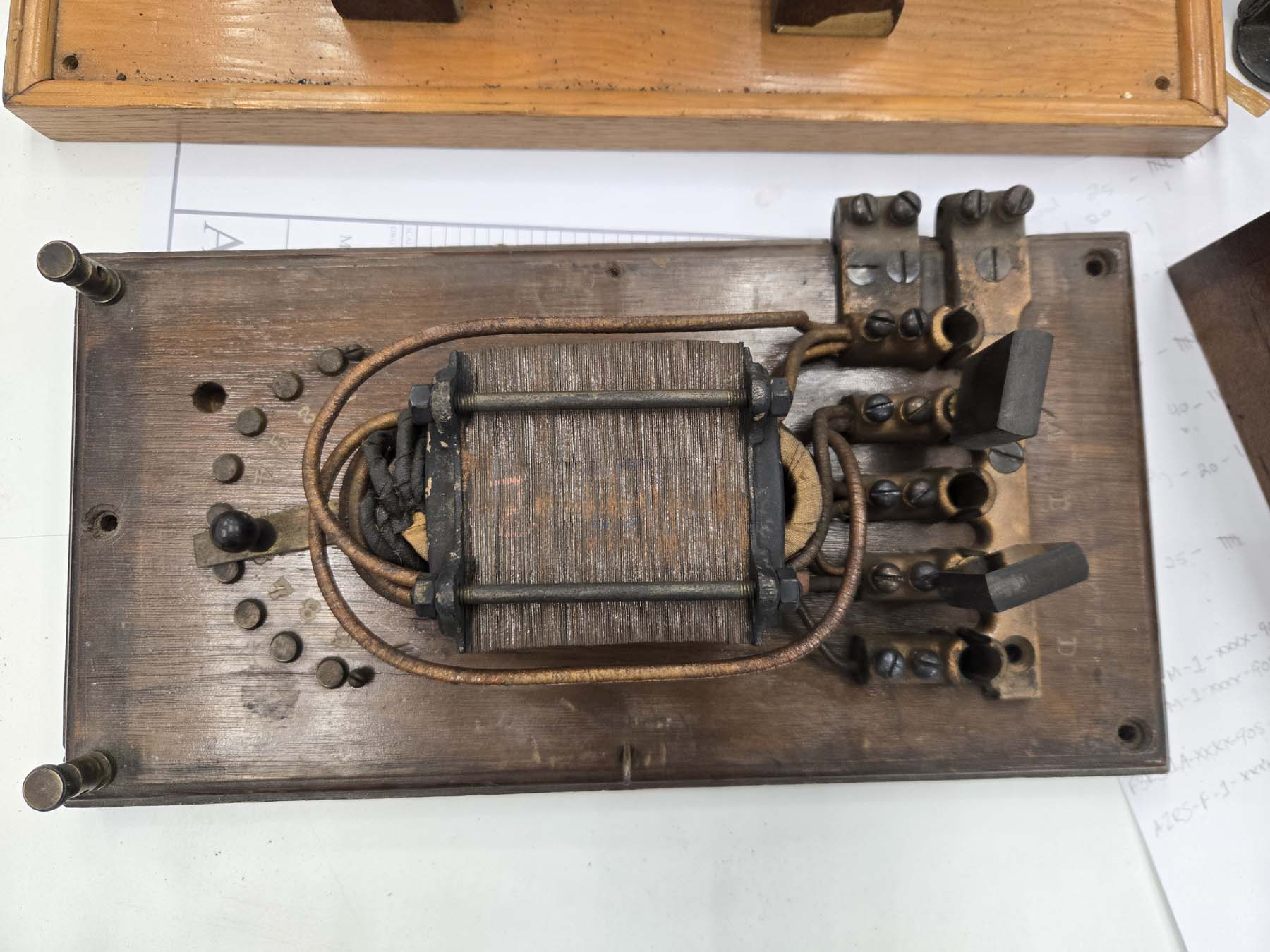
2
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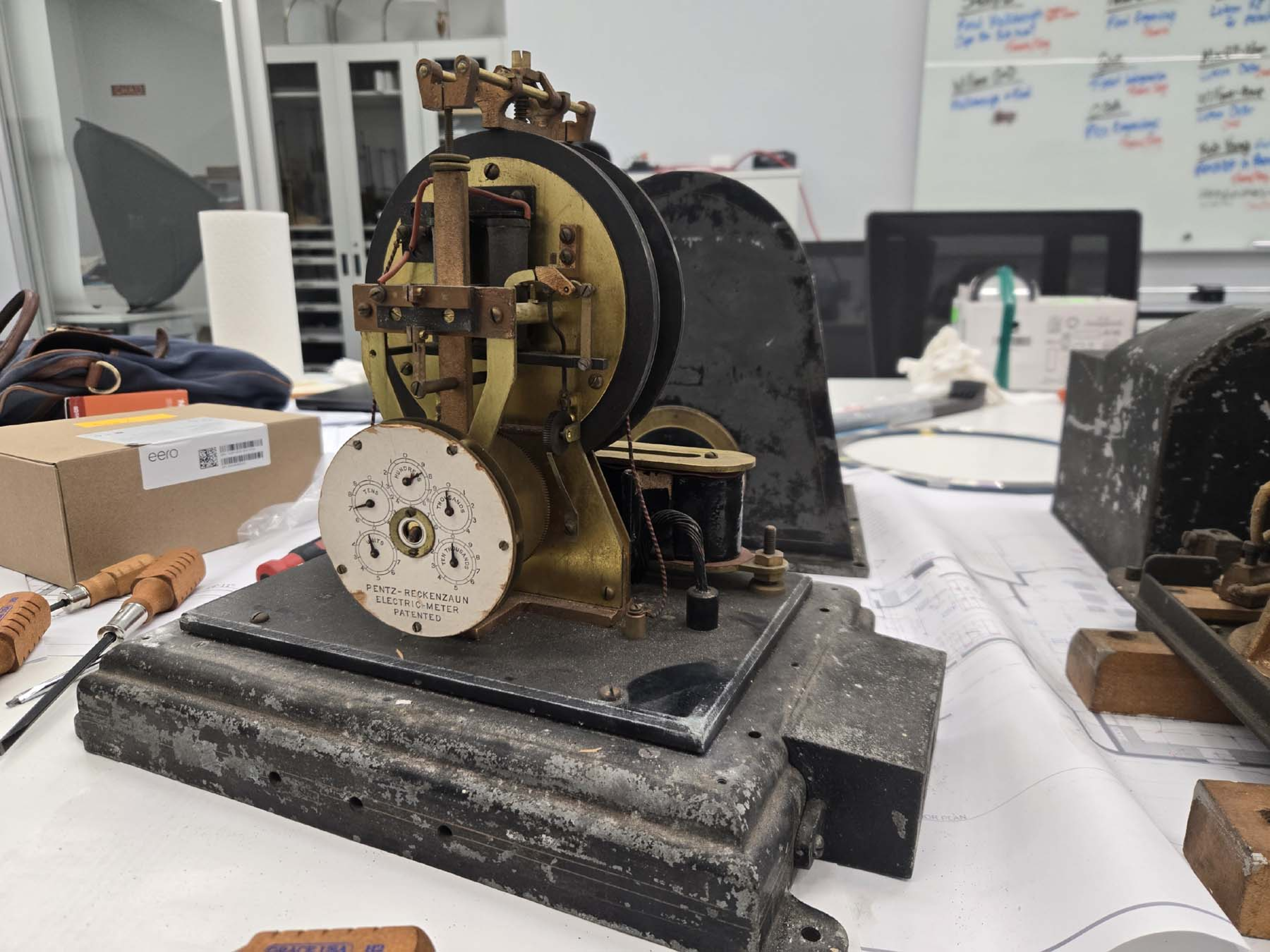
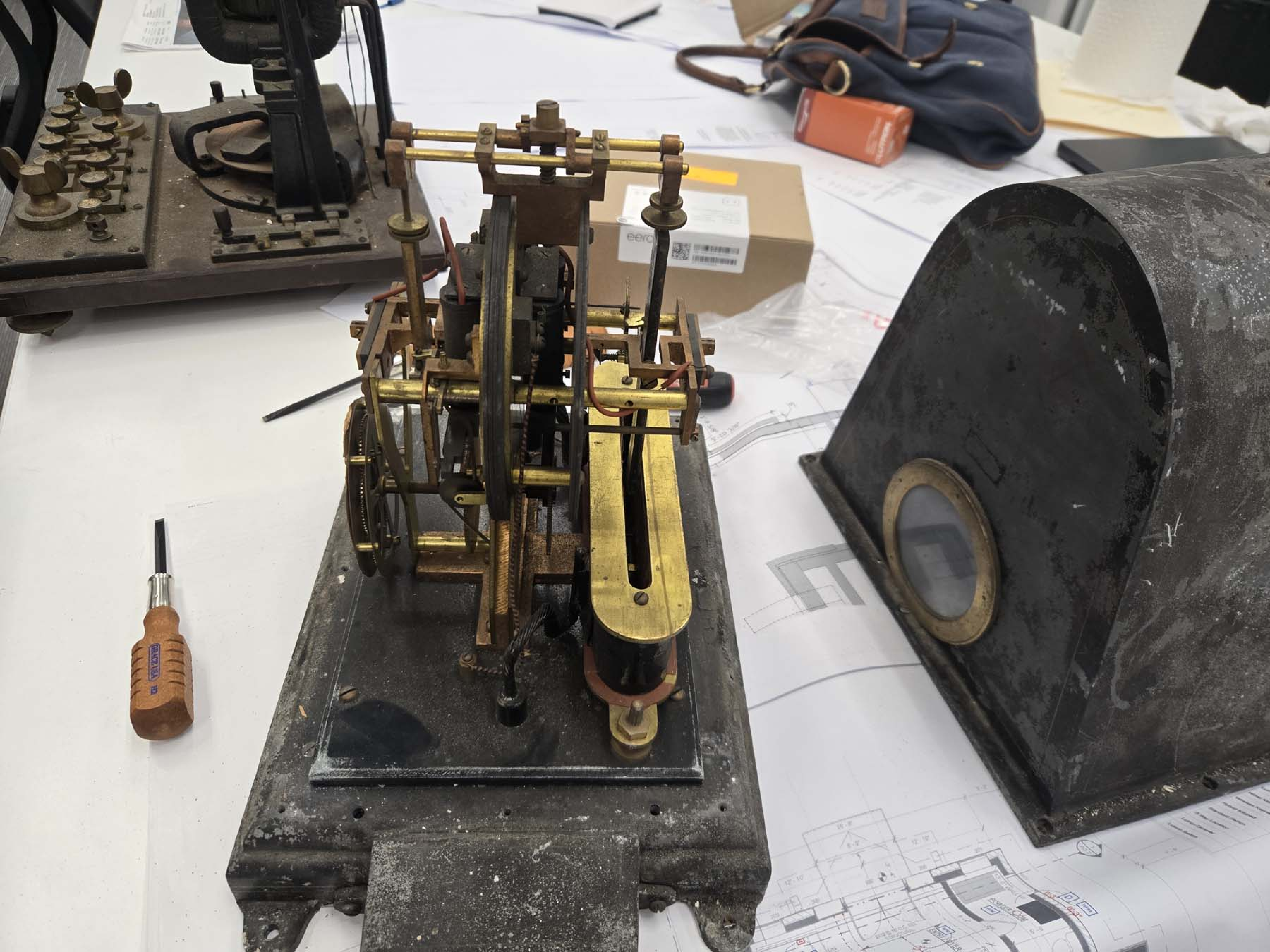
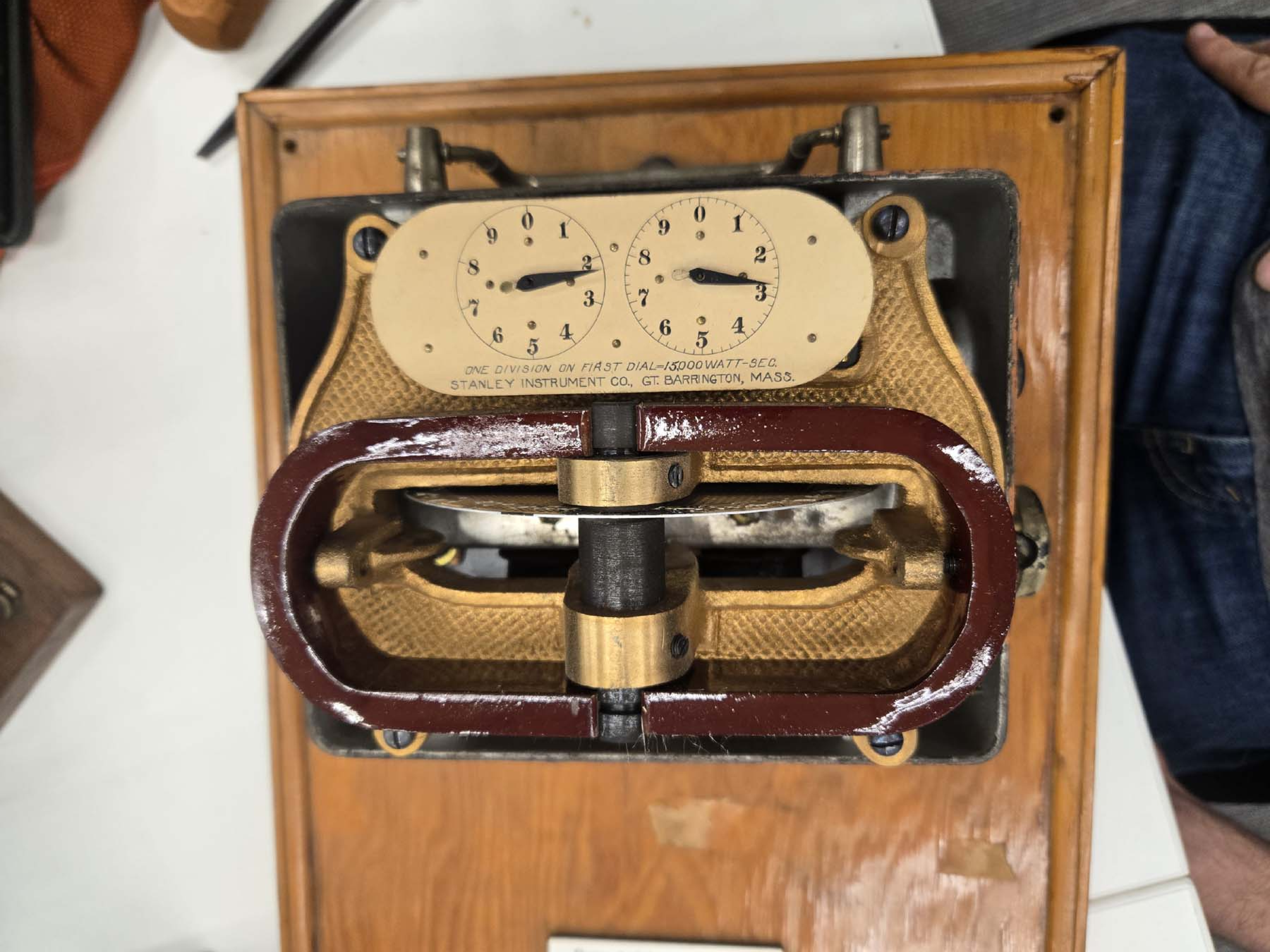
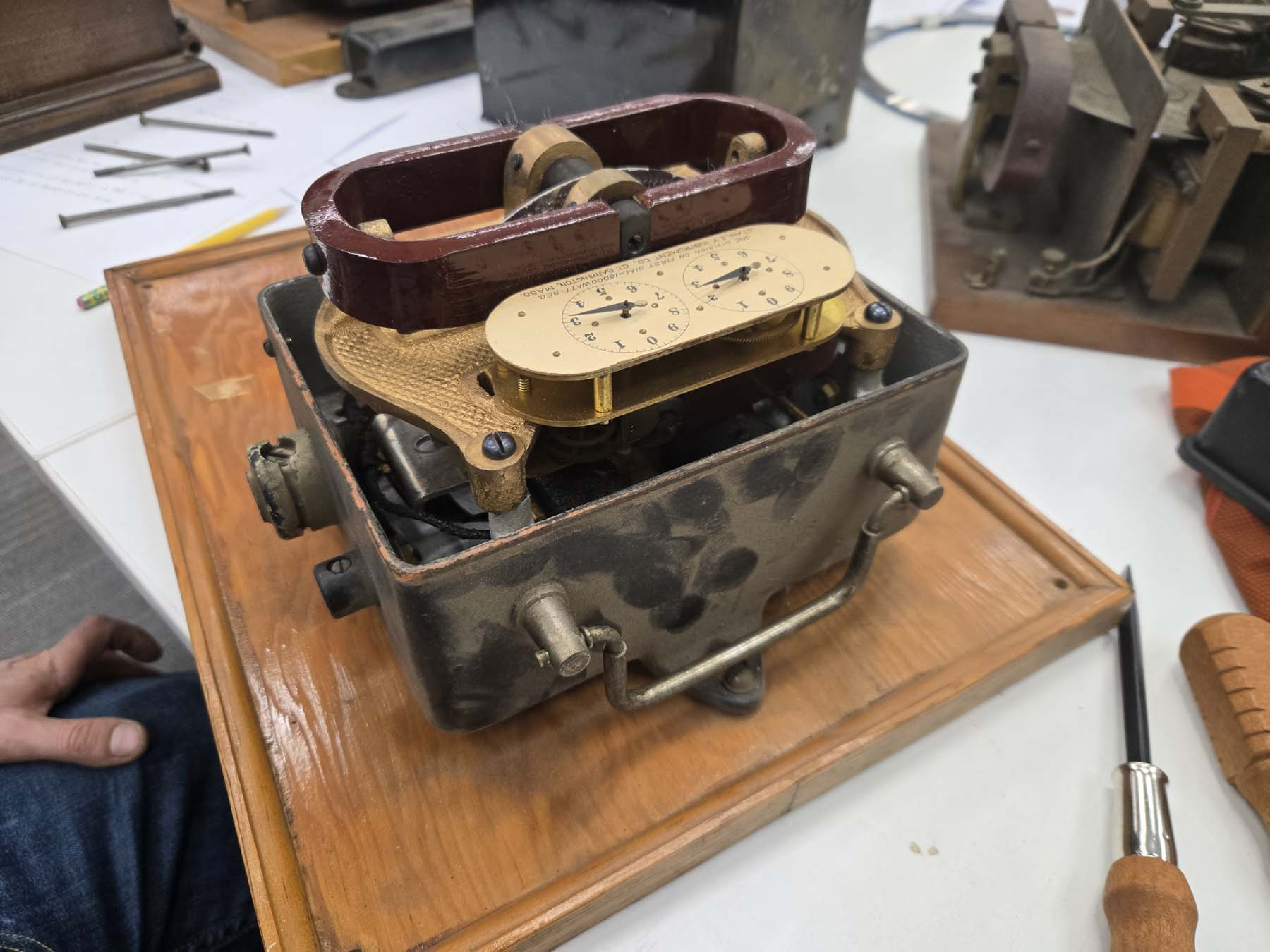
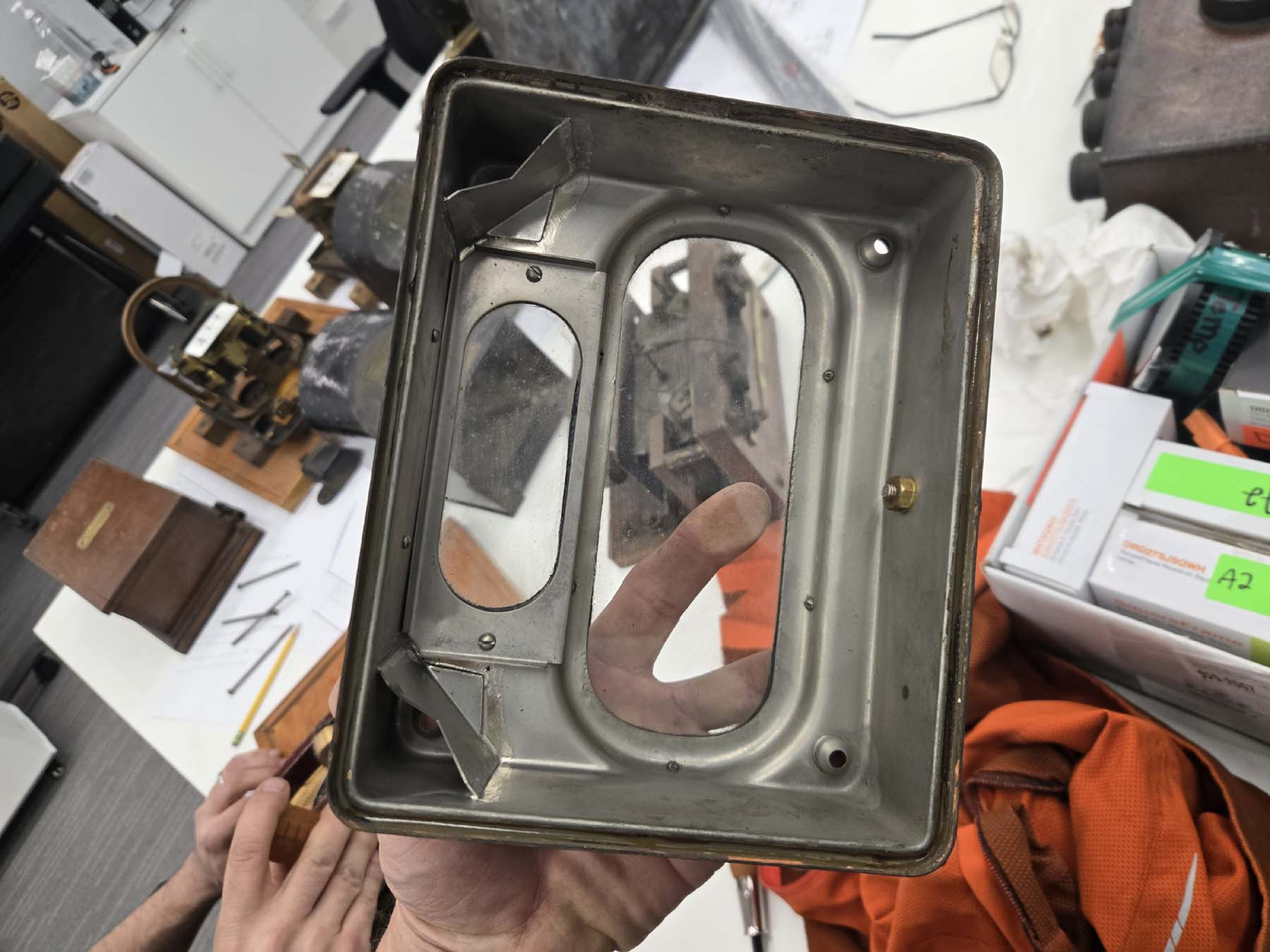
B
D

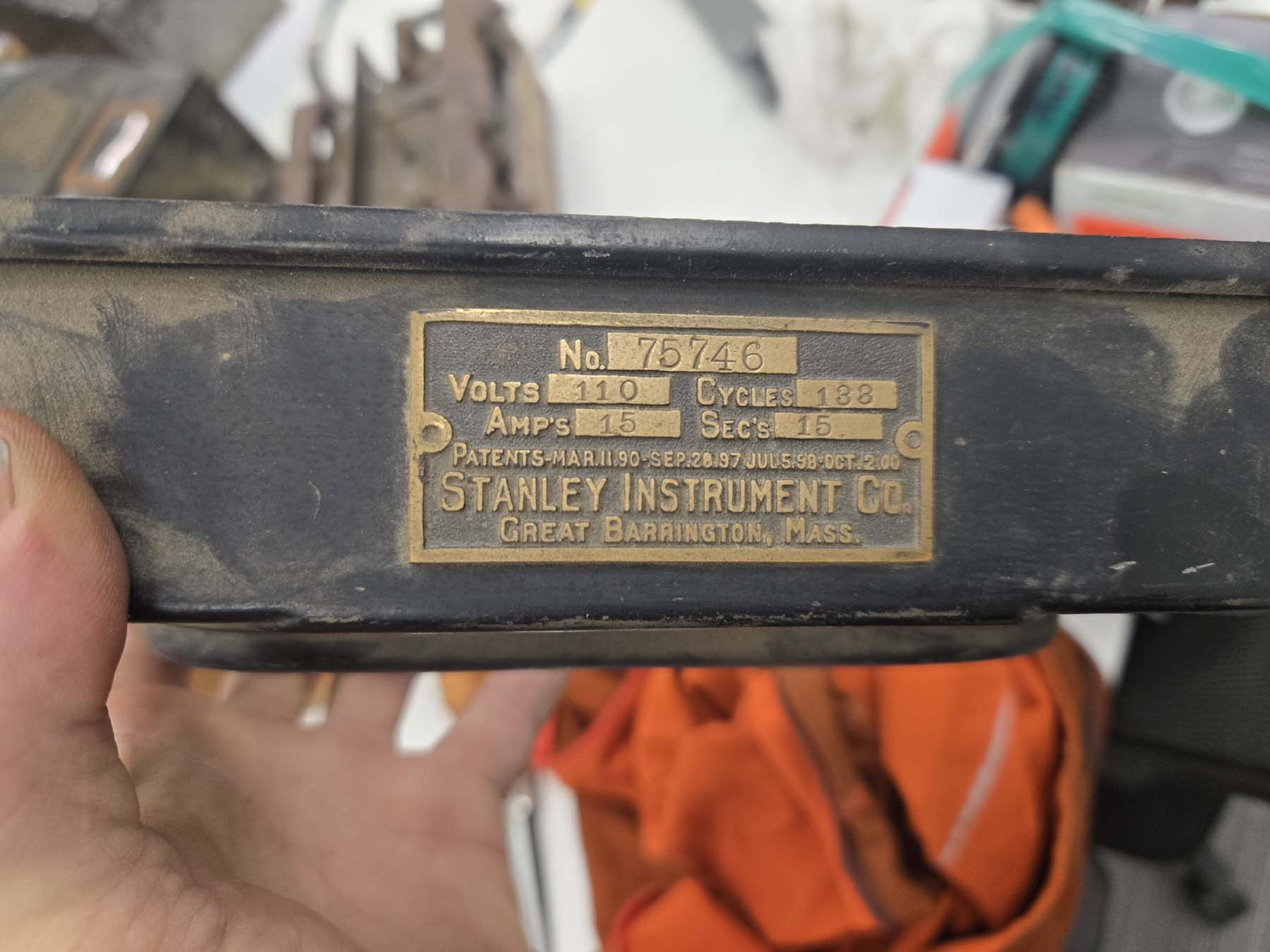

HUNDREDS
TENS
THOUSANDS
UNITS
TEN THOUSANDS
PENTZ-RECKENZAUN
ELECTRIC-METER
PATENTED
eero




ONE DIVISION ON FIRST DIAL=15,000 WATT-SEC.
STANLEY INSTRUMENT CO., GT. BARRINGTON, MASS.


STANLEY INSTRUMENT CO., GT. BARRINGTON, MASS.
ONE DIVISION ON FIRST DIAL=4000 WATT-SEC.





No. 75746

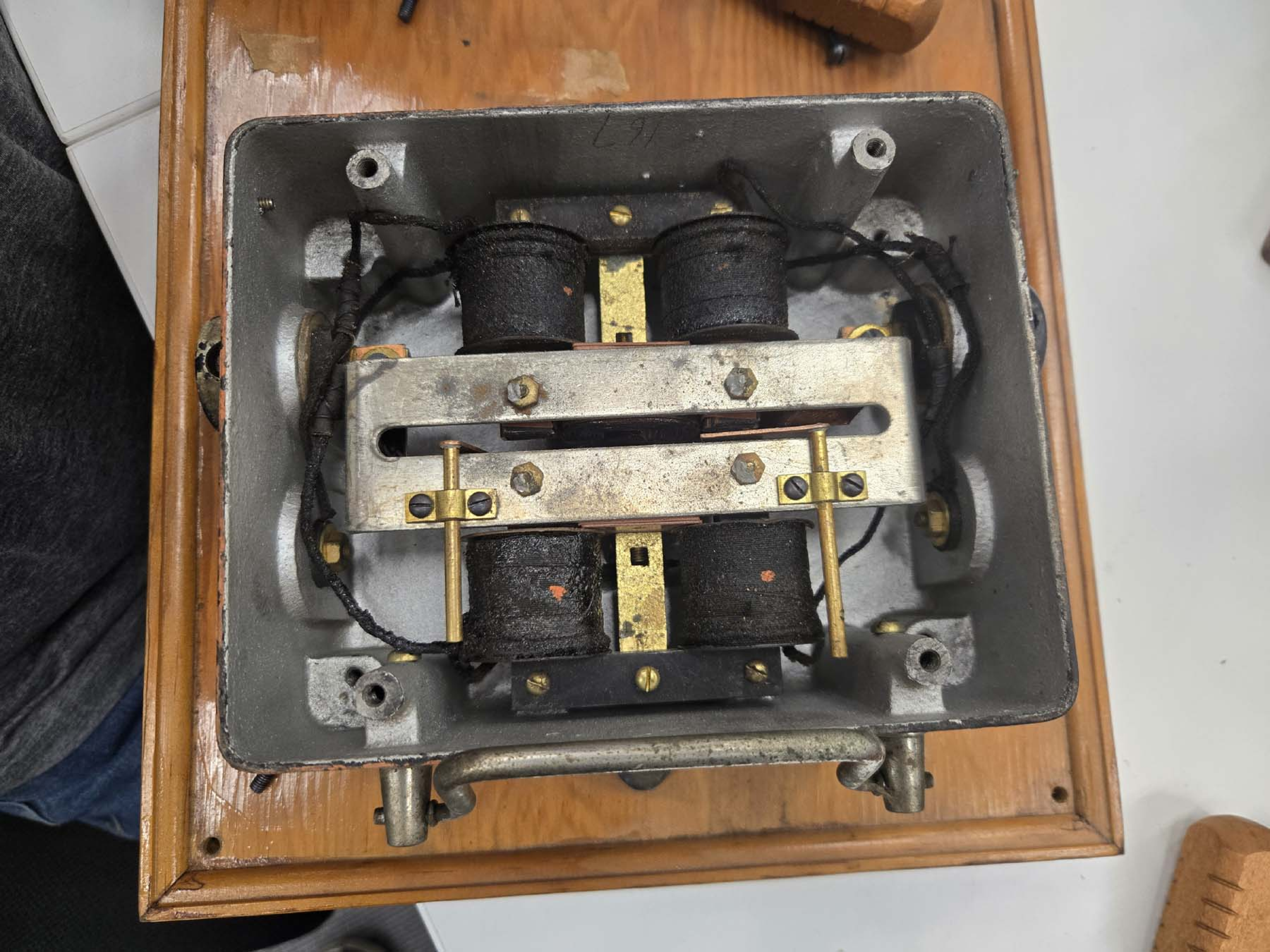
Volts 110 Cycles 138

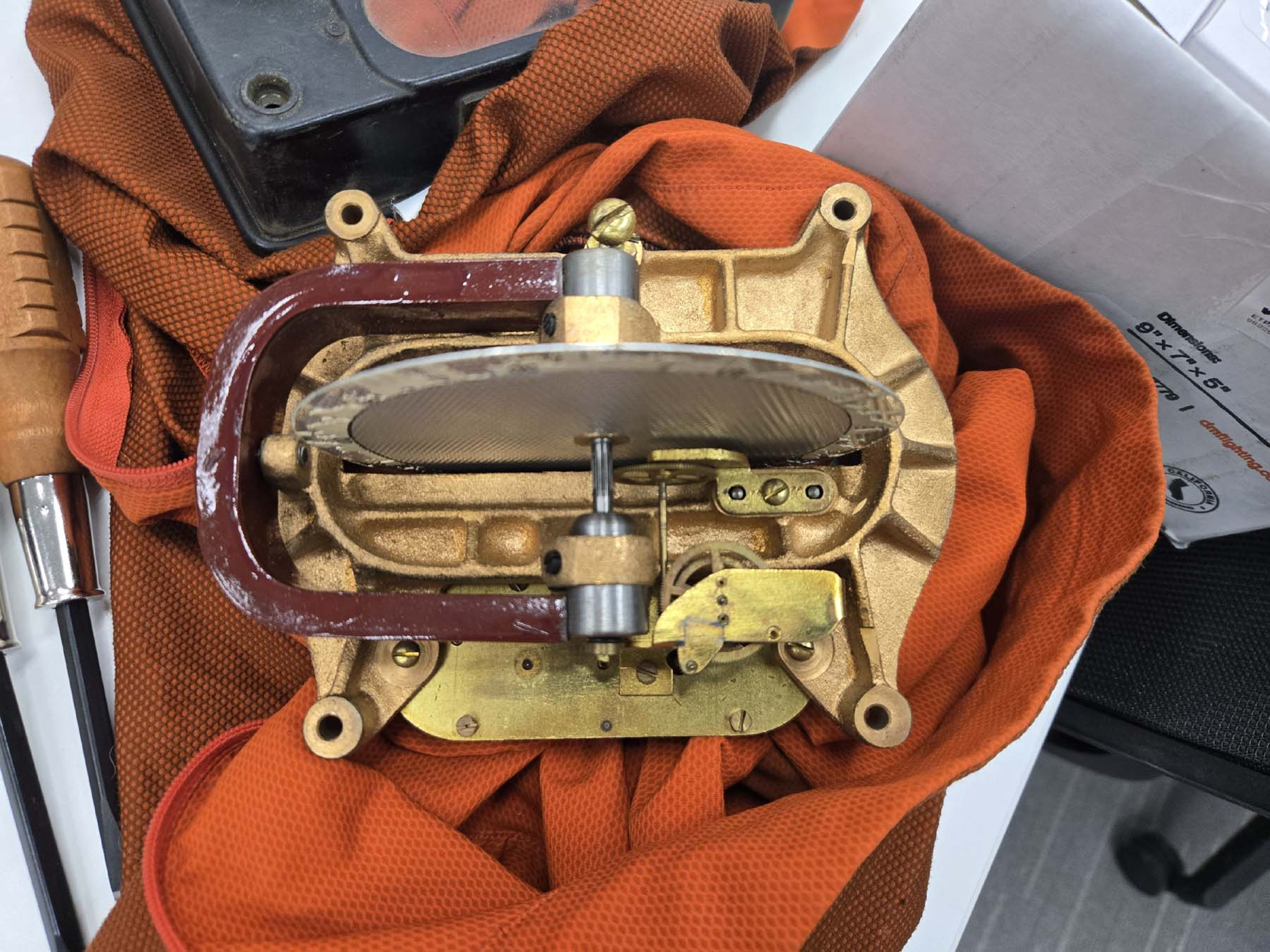
Amp's 15 Sec's 15

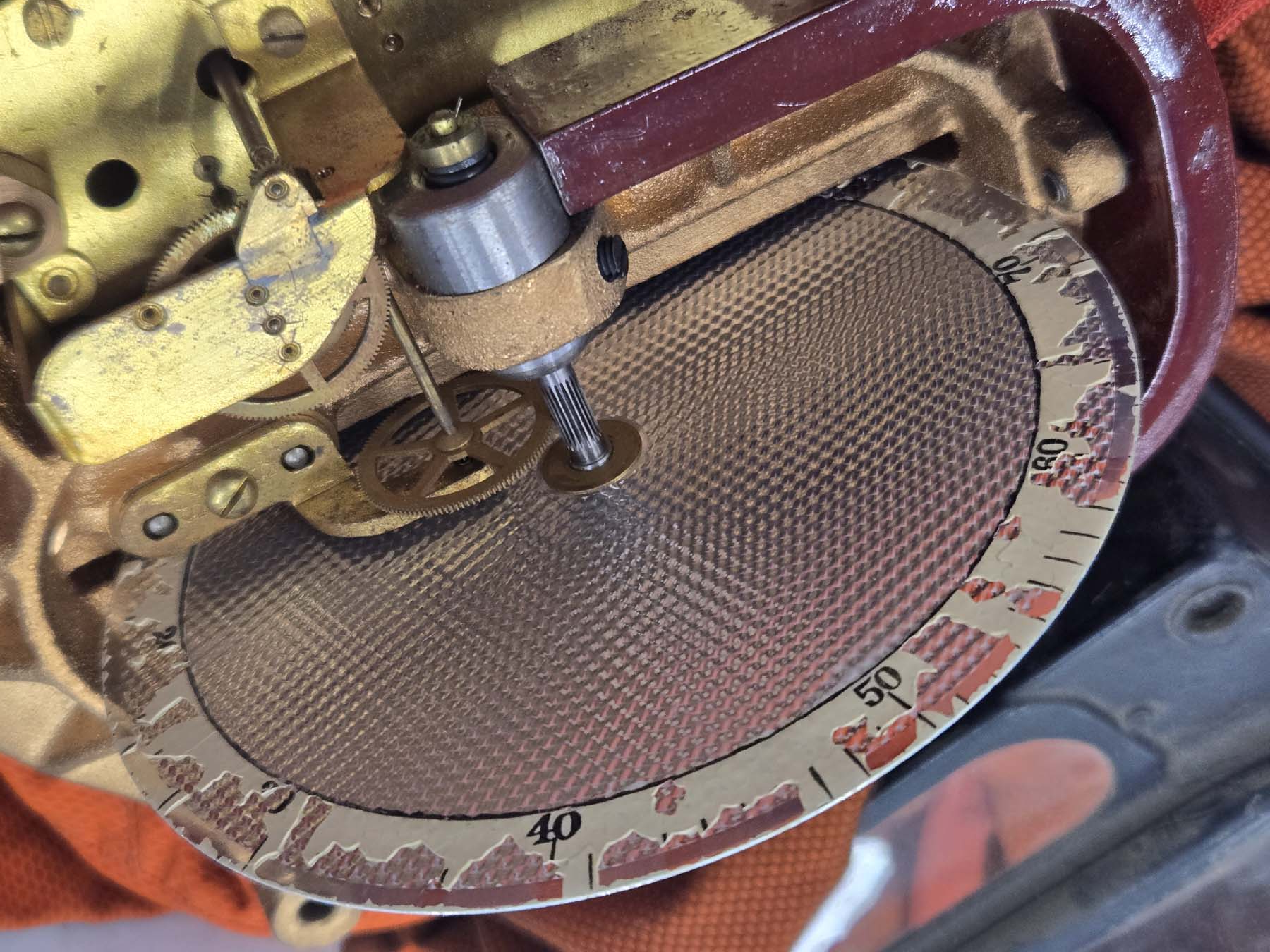
PATENTS-MAR. 11. 90-SEP. 28. 97 JUL. 5. 98-OCT. 2. 00

STANLEY INSTRUMENT CO.

GREAT BARRINGTON, MASS.


167


Dimensions
9" x 7" x 5"


40
50
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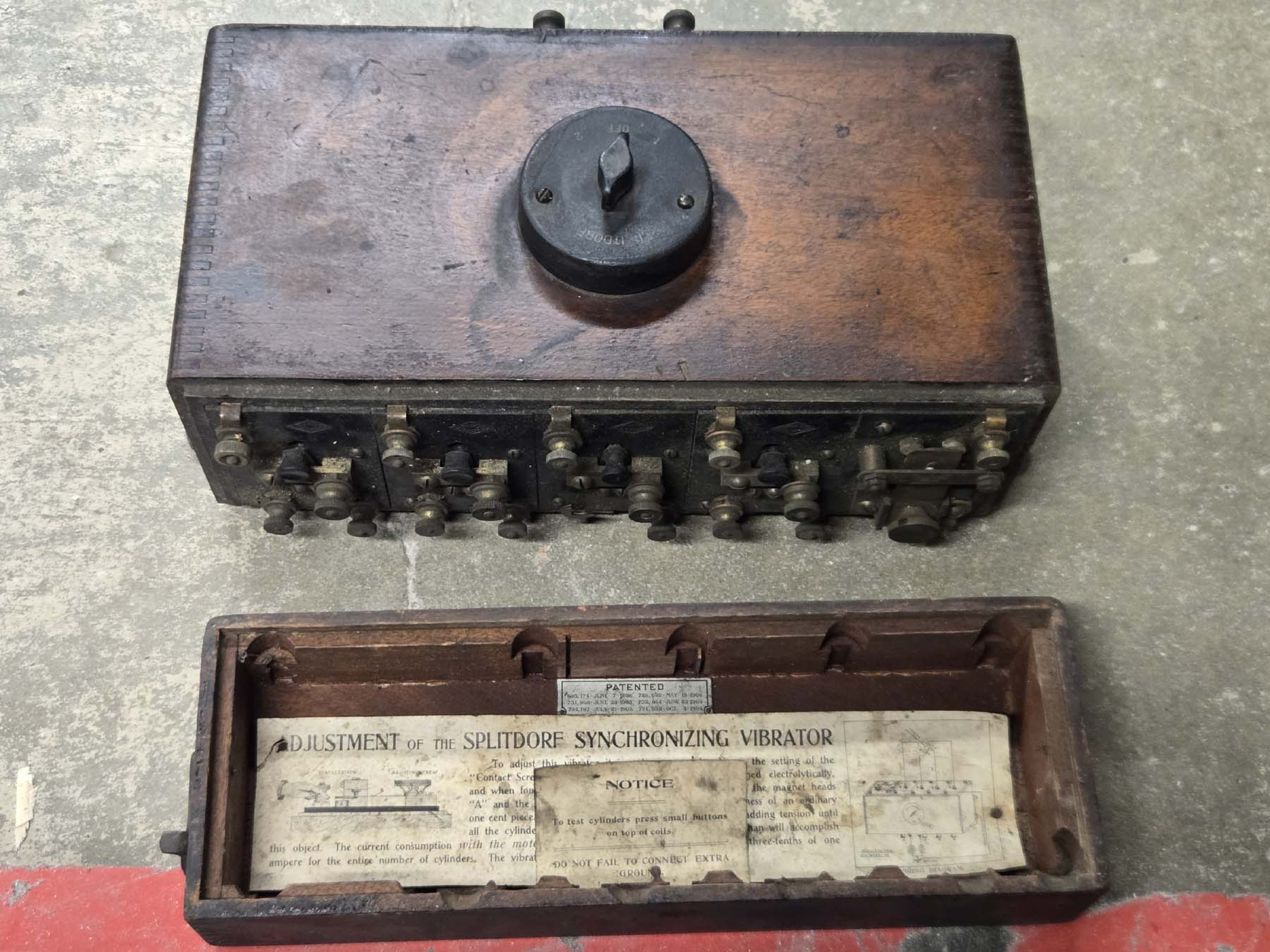
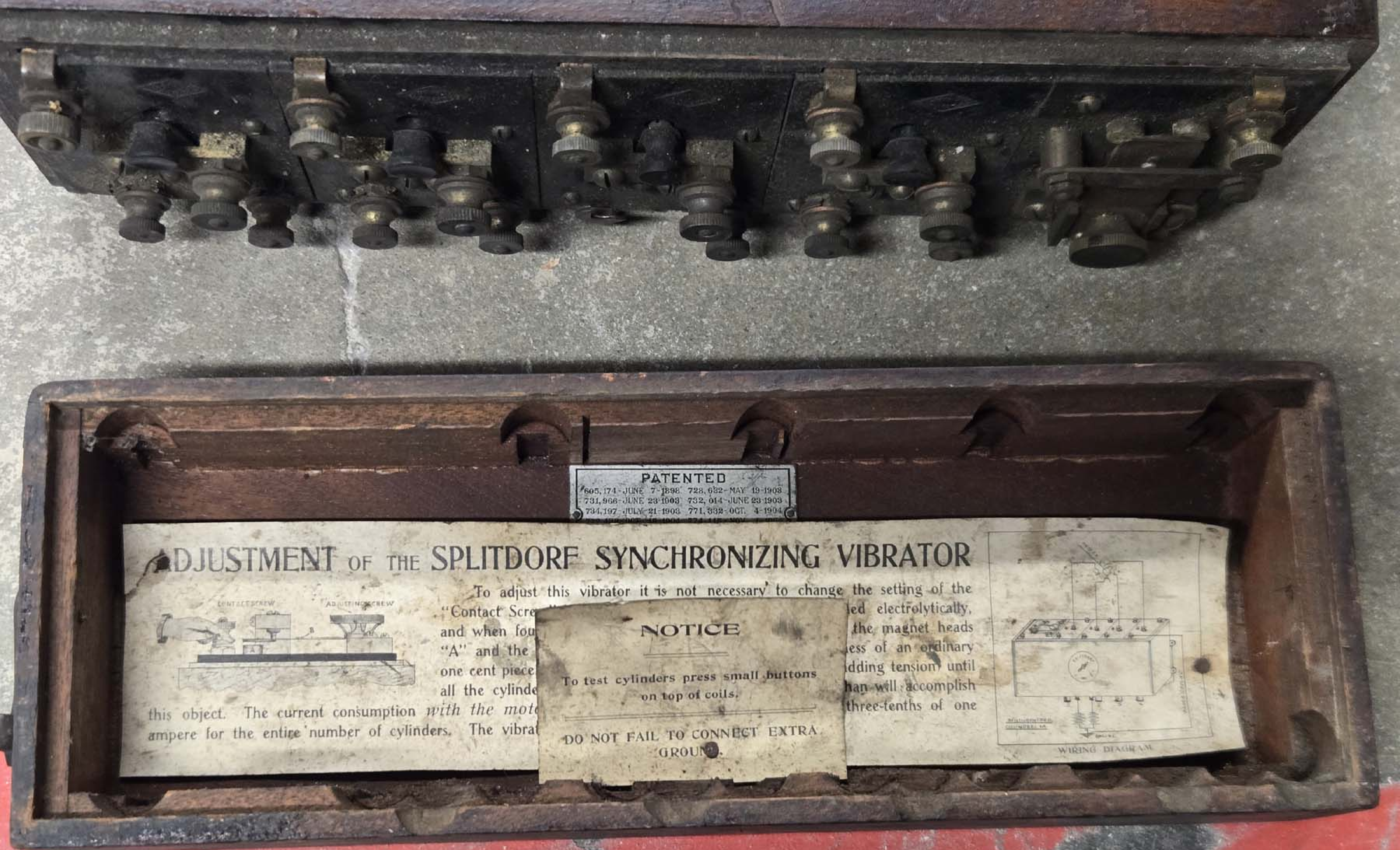

PATENTED
ADJUSTMENT OF THE SPLITDORF SYNCHRONIZING VIBRATOR
To adjust this vibrat
the setting of the
"Contact Scre
ned electrolytically,
and when fou
the magnet heads
"A" and the
ness of an ordinary
one cent piece
adding tension until
all the cylinde
han will accomplish
this object. The current consumption with the moto
three-tenths of one
ampere for the entire number of cylinders. The vibrat
NOTICE
To test cylinders press small buttons on top of coils.
DO NOT FAIL TO CONNECT EXTRA GROUND.



PATENTED

605,174 - JUNE 7 - 1898 728,632 - MAY 19 - 1903
731,966 - JUNE 23 - 1903 732,014 - JUNE 23 - 1903
734,197 - JULY 21 - 1903 771,332 - OCT. 4 - 1904

ADJUSTMENT OF THE SPLITDORF SYNCHRONIZING VIBRATOR

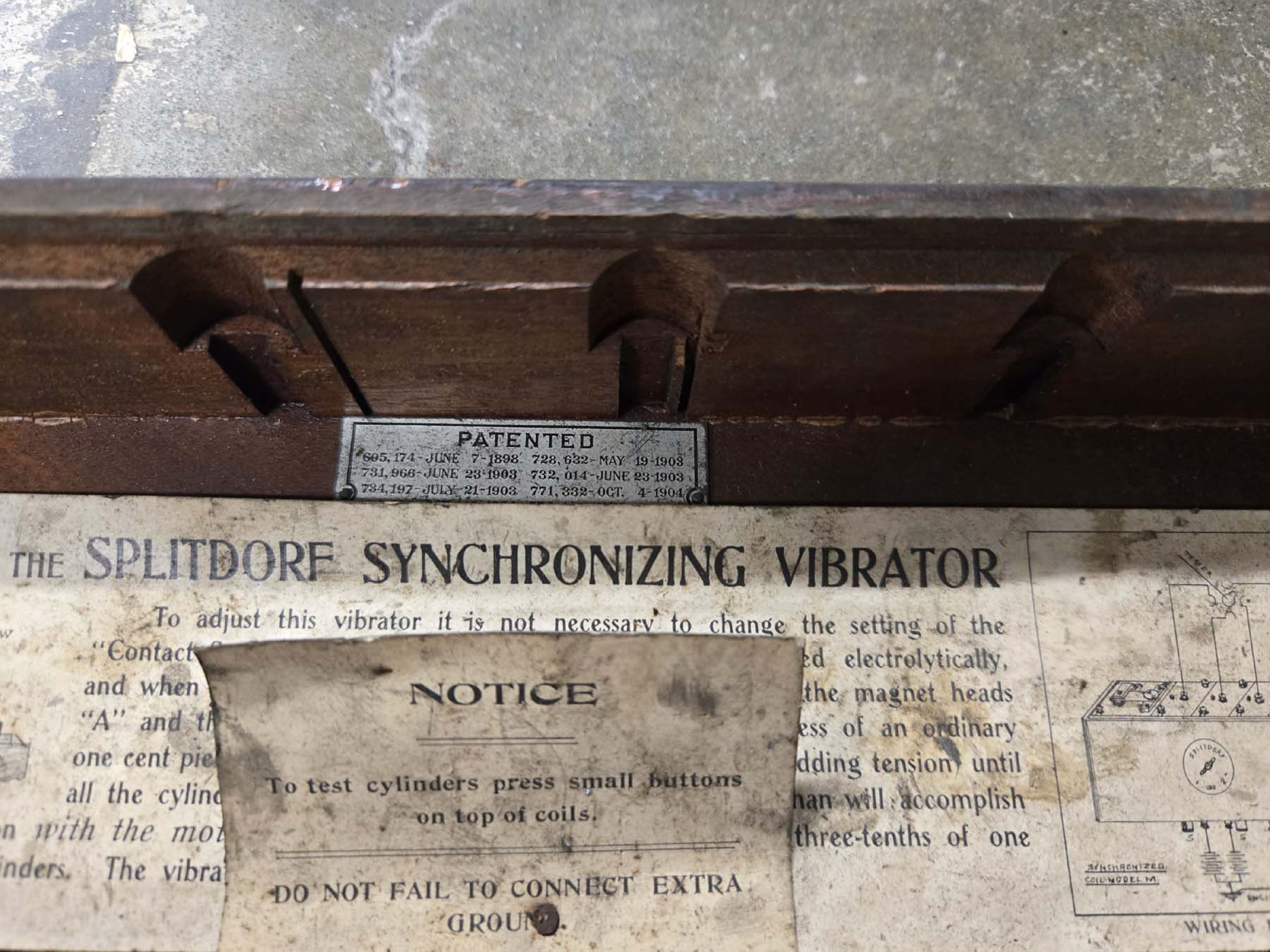
To adjust this vibrator it is not necessary to change the setting of the
"Contact Scre … led electrolytically,
and when fou … the magnet heads
"A" and the … ess of an ordinary
one cent piece … dding tension until
all the cylinde … han will accomplish
this object. The current consumption *with the mot* … three-tenths of one
ampere for the entire number of cylinders. The vibrat

NOTICE

To test cylinders press small buttons on top of coils.

DO NOT FAIL TO CONNECT EXTRA GROUND.

WIRING DIAGRAM



PATENTED
605,174 - JUNE 7-1898 728,632 - MAY 19-1903
731,966 - JUNE 23-1903 732,014 - JUNE 23-1903
734,197 - JULY 21-1903 771,332 - OCT. 4-1904

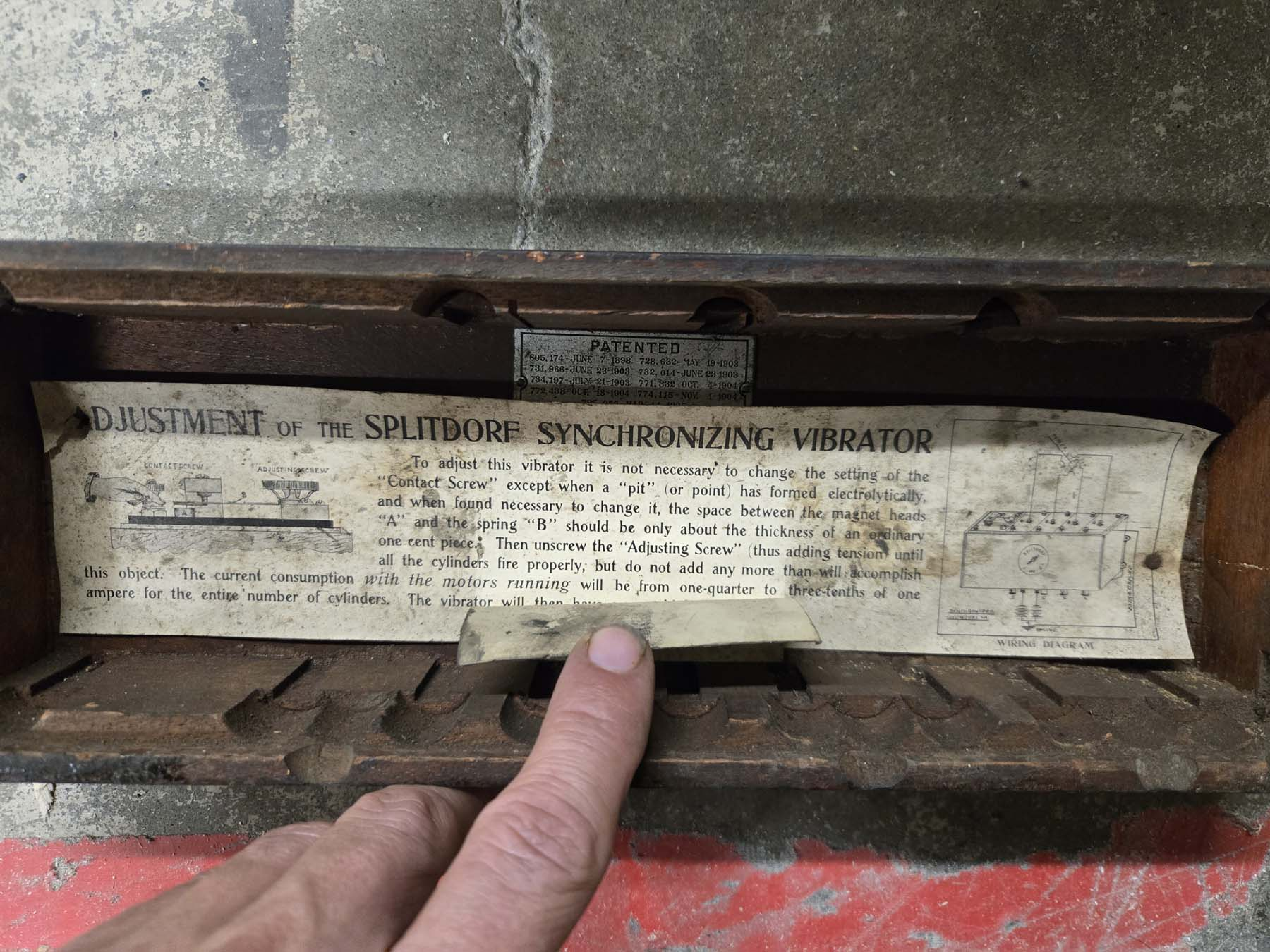
THE SPLITDORF SYNCHRONIZING VIBRATOR

To adjust this vibrator it is not necessary to change the setting of the
"Contact
ed electrolytically,
and when
the magnet heads
"A" and th
ess of an ordinary
one cent pie
dding tension until
all the cylind
han will accomplish
n *with the mot*
three-tenths of one
inders. The vibra

NOTICE

To test cylinders press small buttons on top of coils.

DO NOT FAIL TO CONNECT EXTRA GROUND.

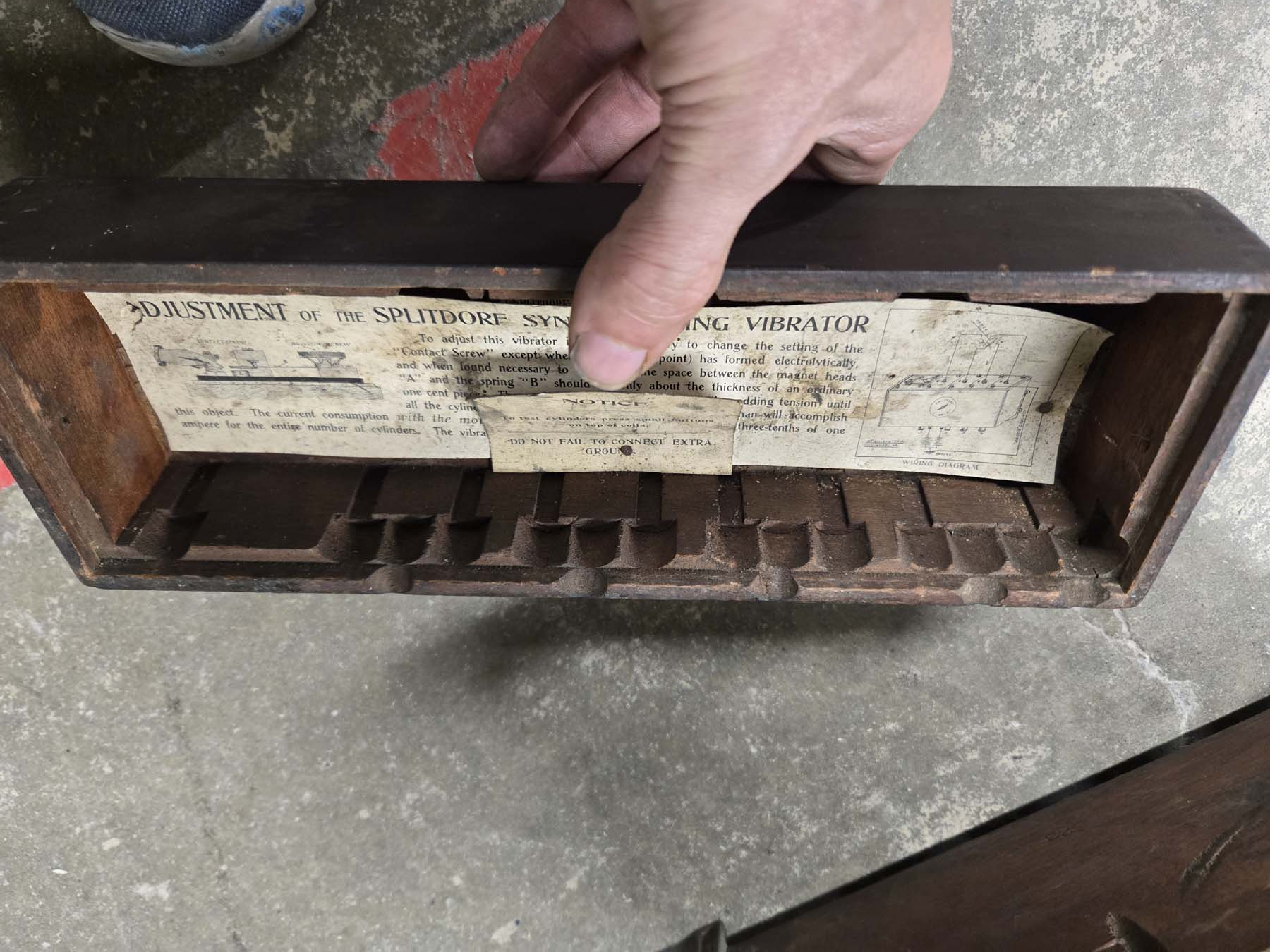


PATENTED
605,174 - JUNE 7-1898 728,632 - MAY 19-1903
731,966 - JUNE 23-1903 732,014 - JUNE 23-1903
734,197 - JULY 21-1903 771,332 - OCT. 4-1904
772,438 - OCT. 18-1904 774,115 - NOV. 1-1904

DJUSTMENT OF THE SPLITDORF SYNCHRONIZING VIBRATOR

To adjust this vibrator it is not necessary to change the setting of the "Contact Screw" except when a "pit" (or point) has formed electrolytically, and when found necessary to change it, the space between the magnet heads "A" and the spring "B" should be only about the thickness of an ordinary one cent piece. Then unscrew the "Adjusting Screw" (thus adding tension until all the cylinders fire properly, but do not add any more than will accomplish this object. The current consumption *with the motors running* will be from one-quarter to three-tenths of one ampere for the entire number of cylinders. The vibrator will then h

WIRING DIAGRAM



ADJUSTMENT OF THE SPLITDORF SYN ING VIBRATOR

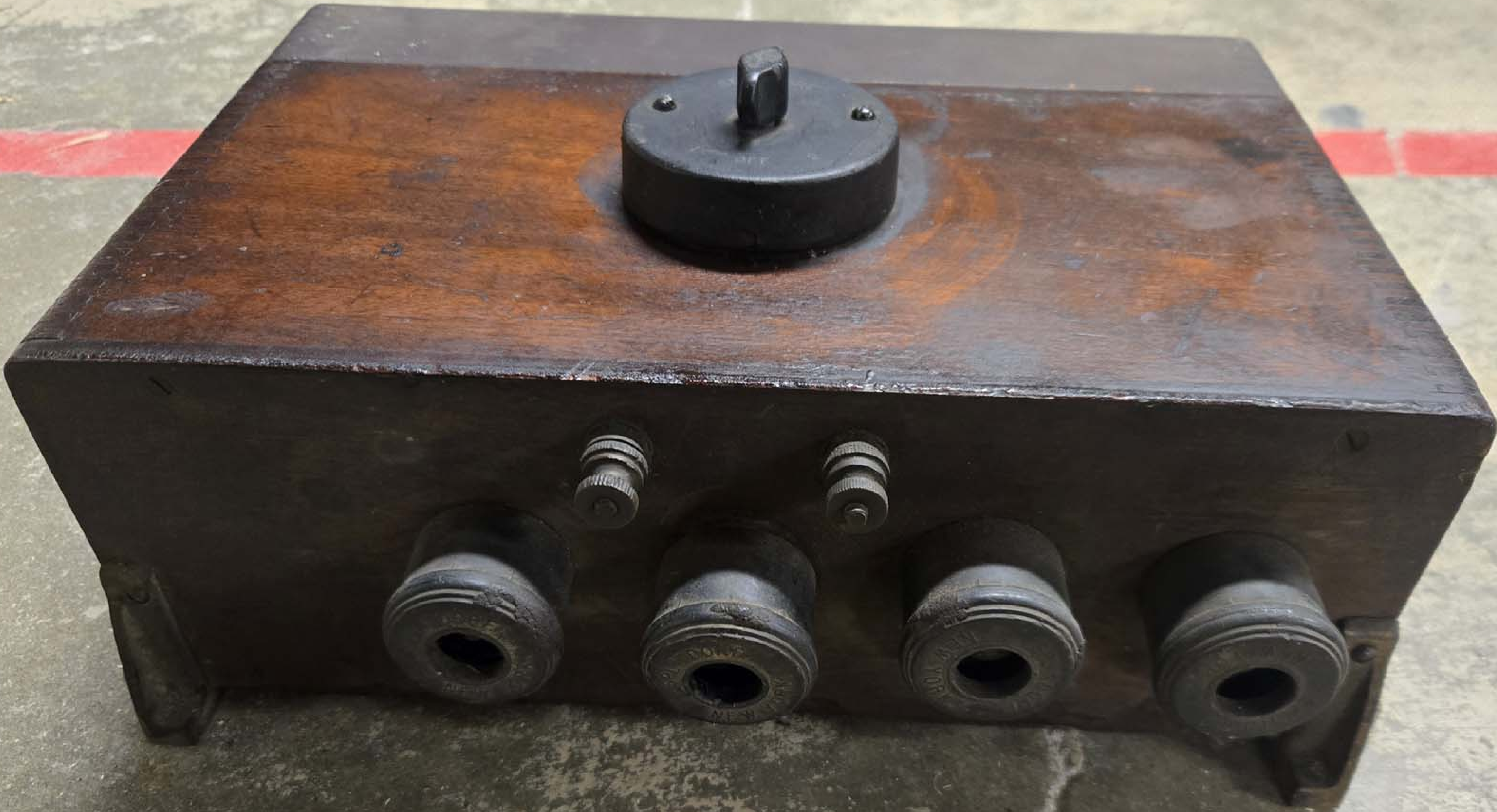
To adjust this vibrator y to change the setting of the
"Contact Screw" except whe point) has formed electrolytically,
and when found necessary to ne space between the magnet heads
"A" and the spring "B" shoulo nly about the thickness of an ordinary
one cent piece. Th dding tension until
all the cylin han will accomplish
this object. The current consumption *with the mo* three-tenths of one
ampere for the entire number of cylinders. The vibra

NOTICE

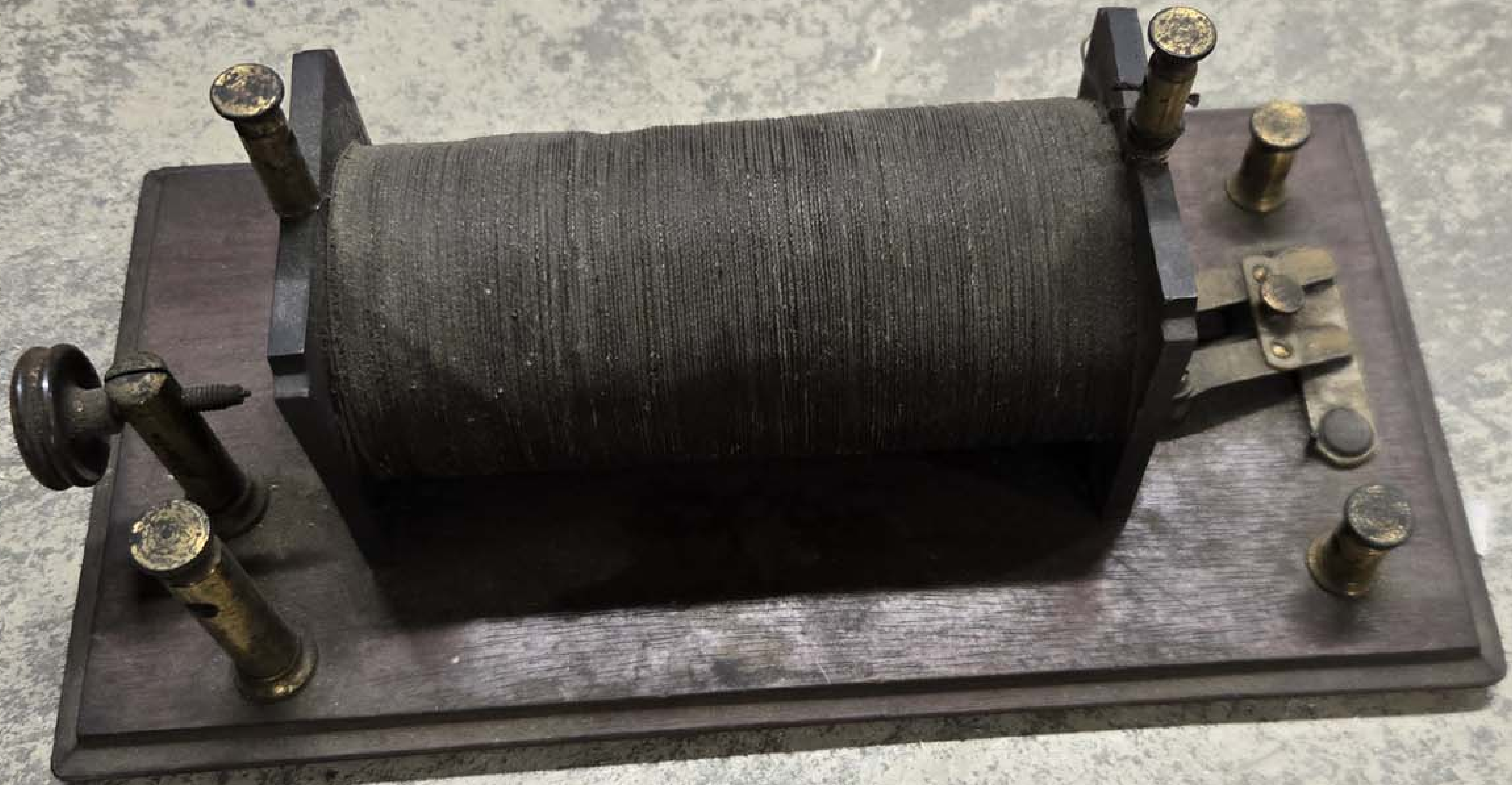
To test cylinders press small buttons
on top of coils.

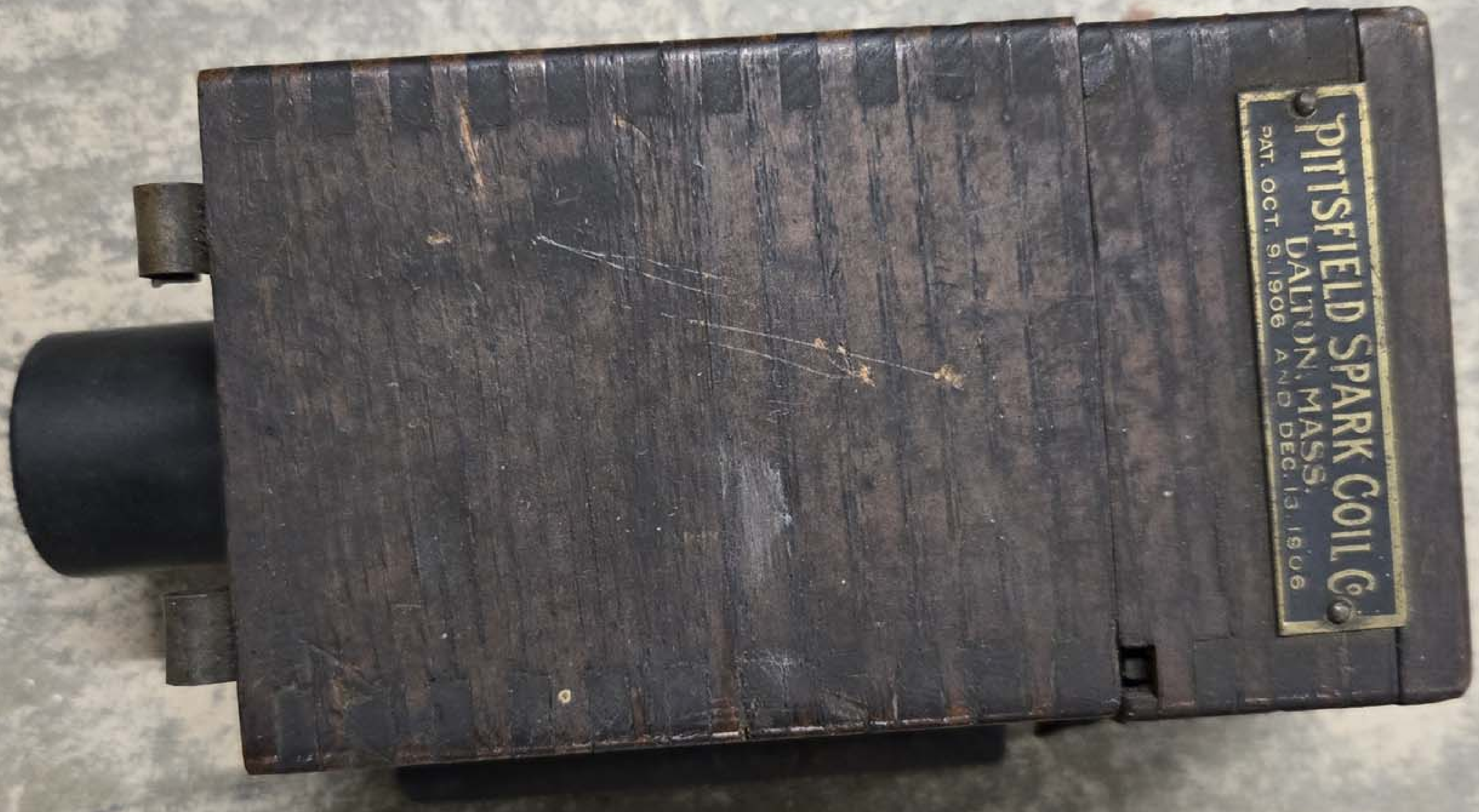
DO NOT FAIL TO CONNECT EXTRA
GROUND.

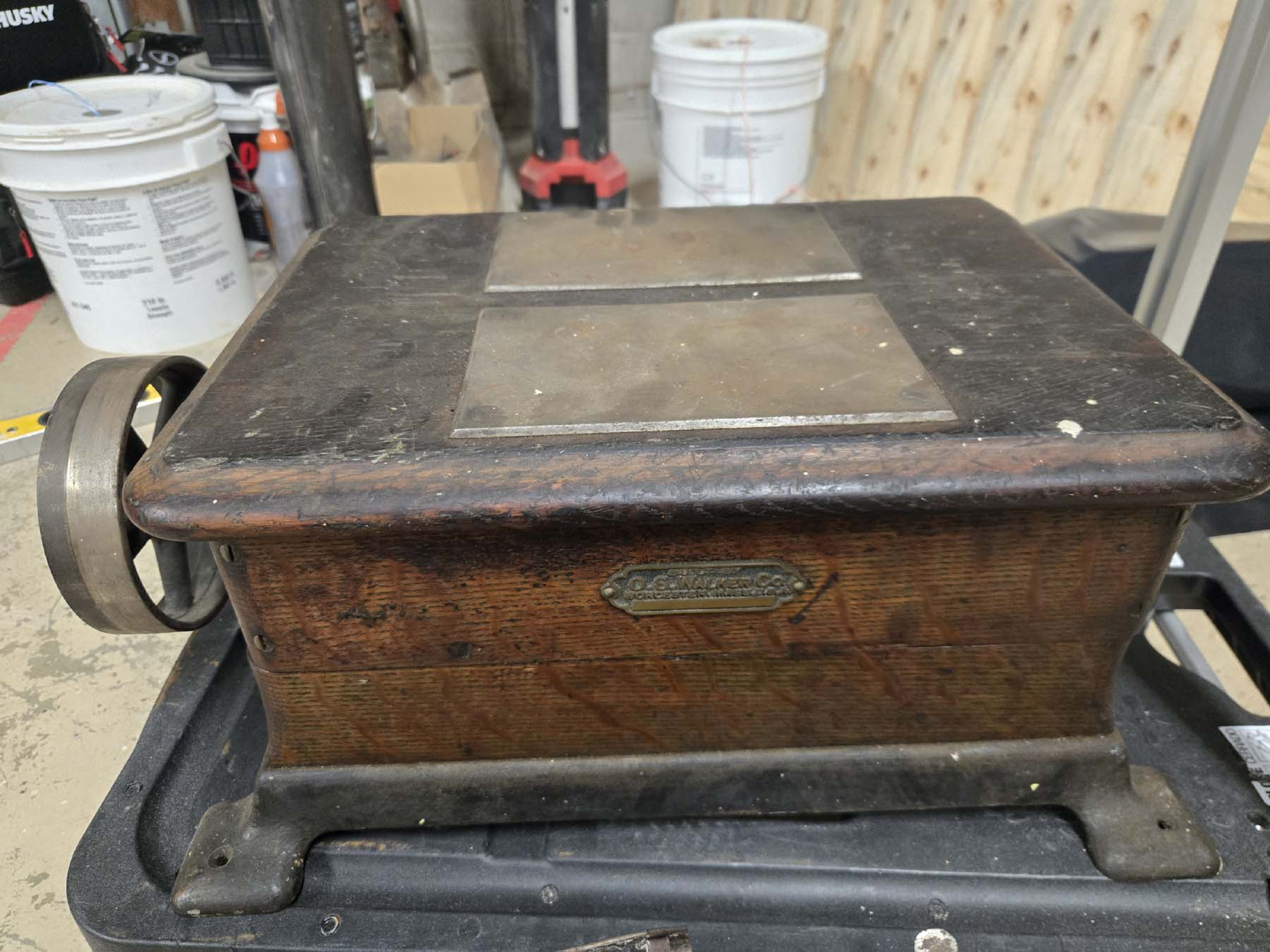
1
OFF
2

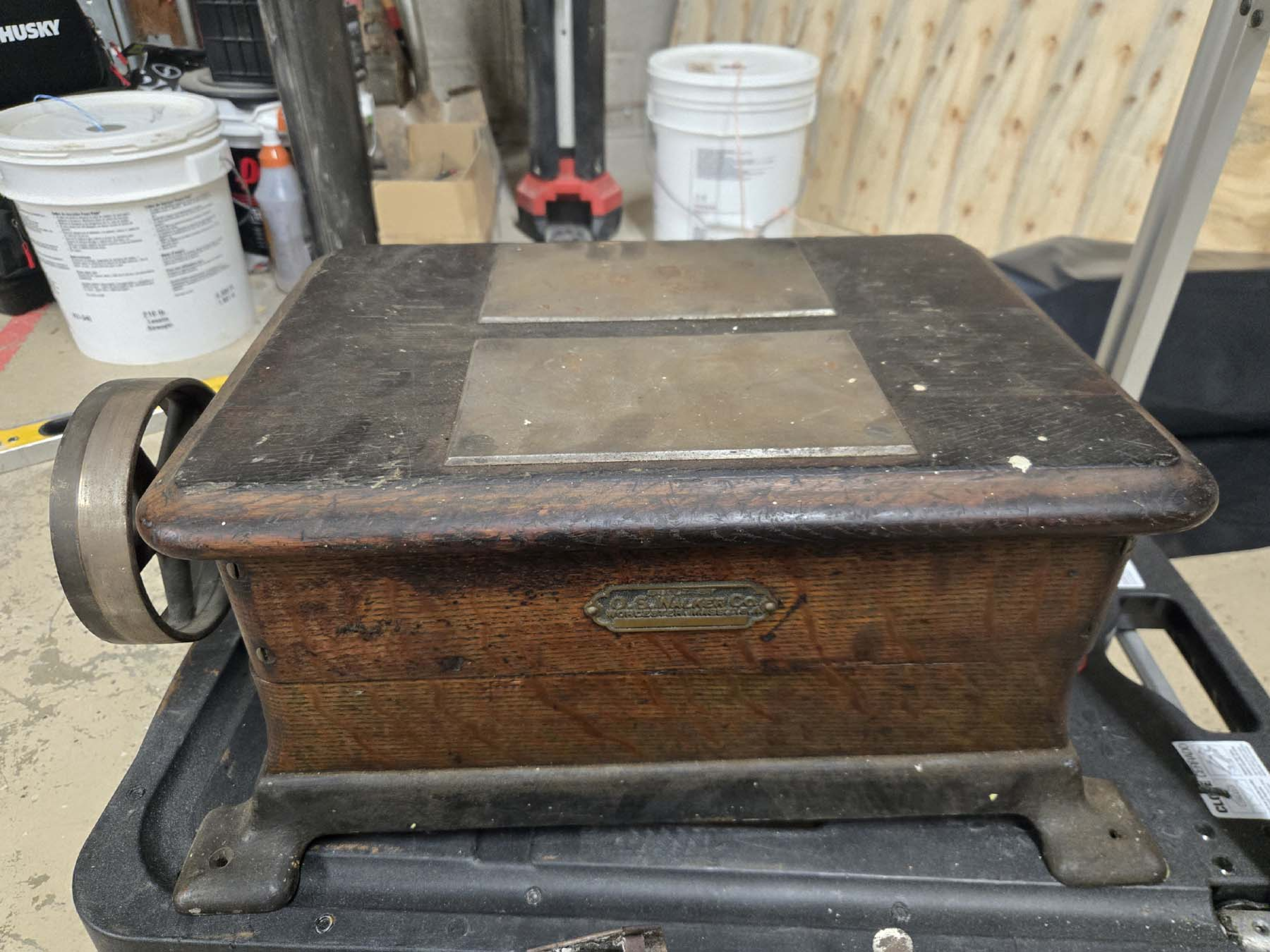


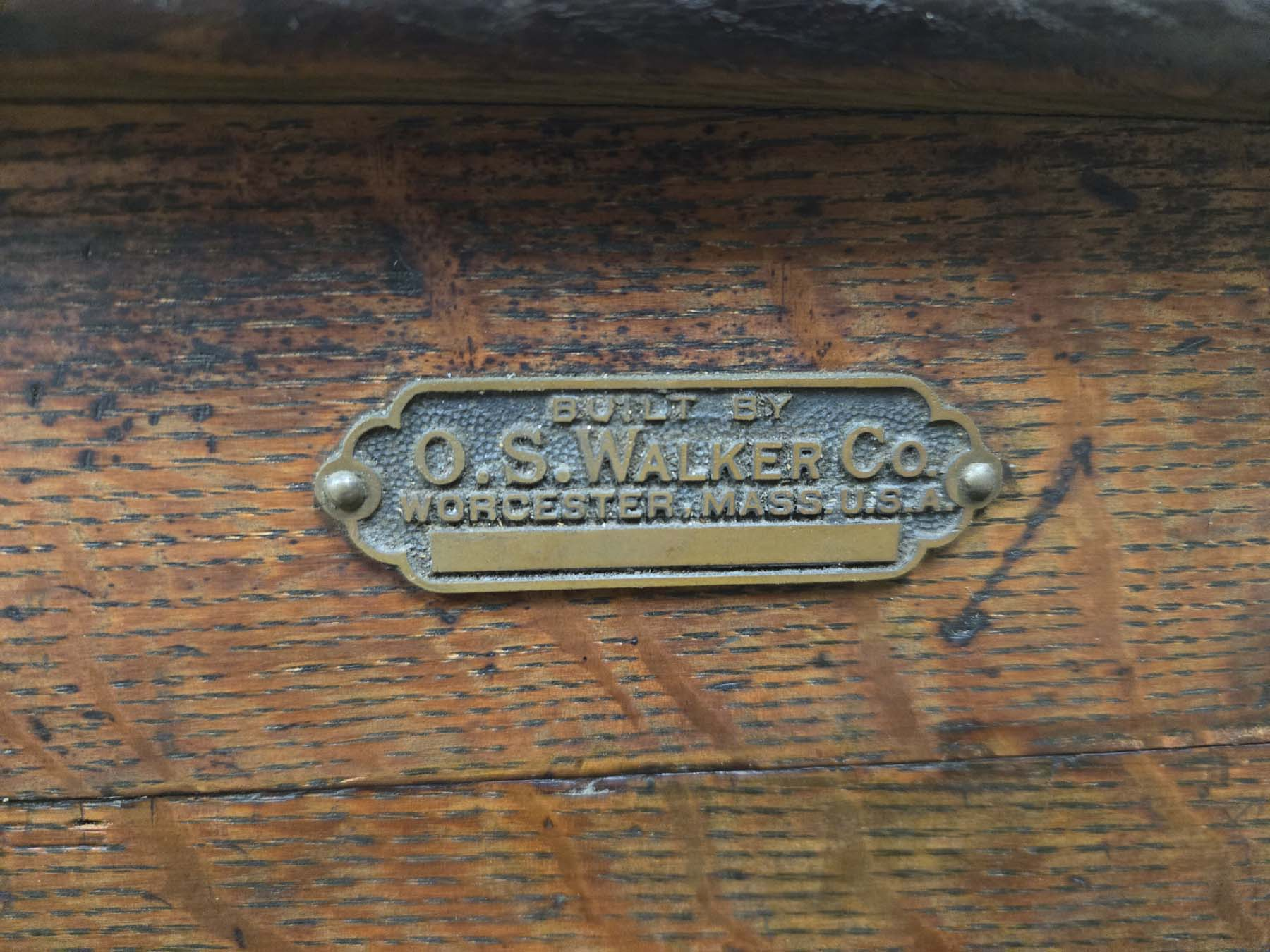
OFF

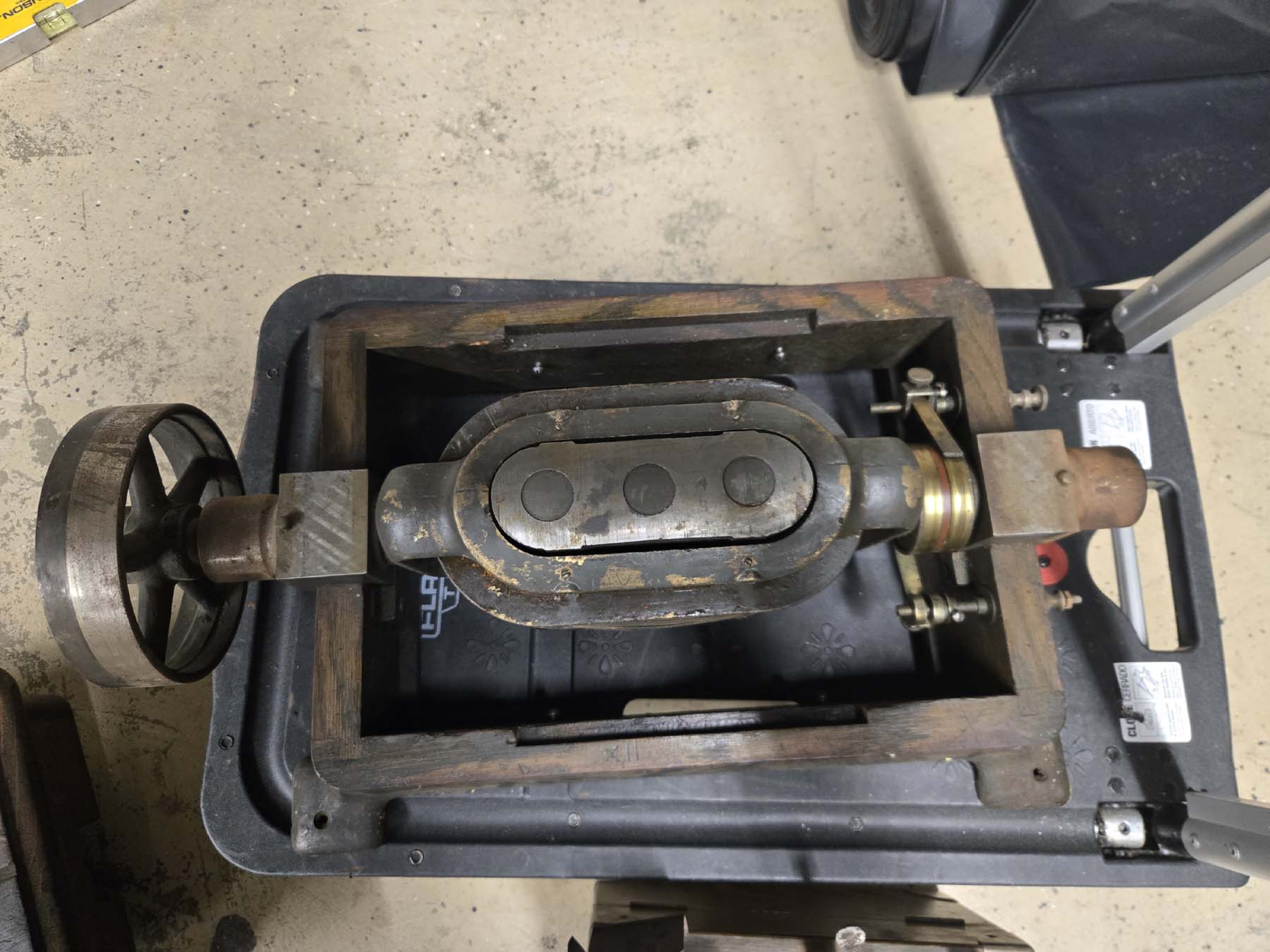


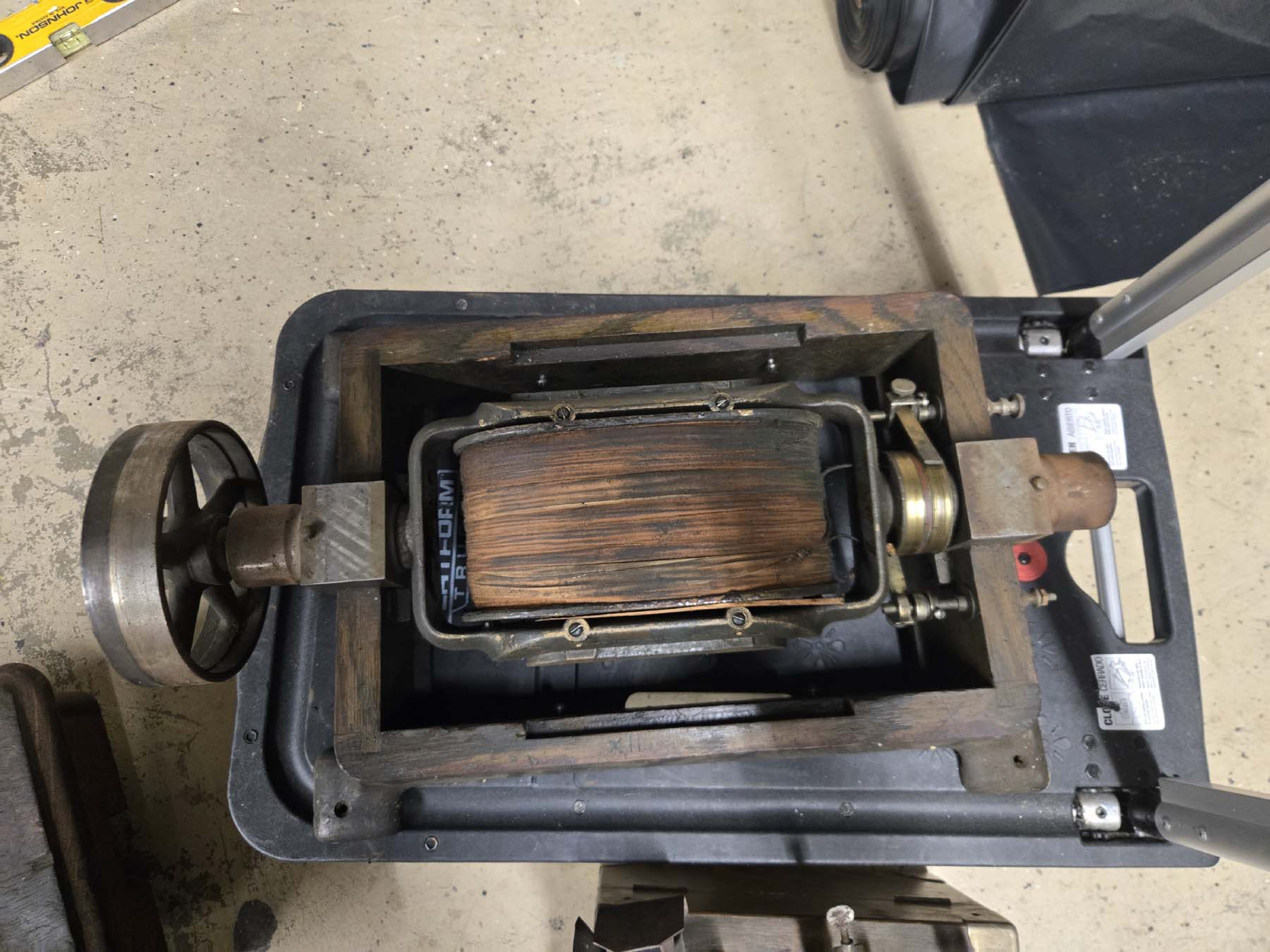

PITTSFIELD SPARK COIL Co.
DALTON, MASS.
PAT. OCT. 9, 1906 AND DEC. 13, 1906

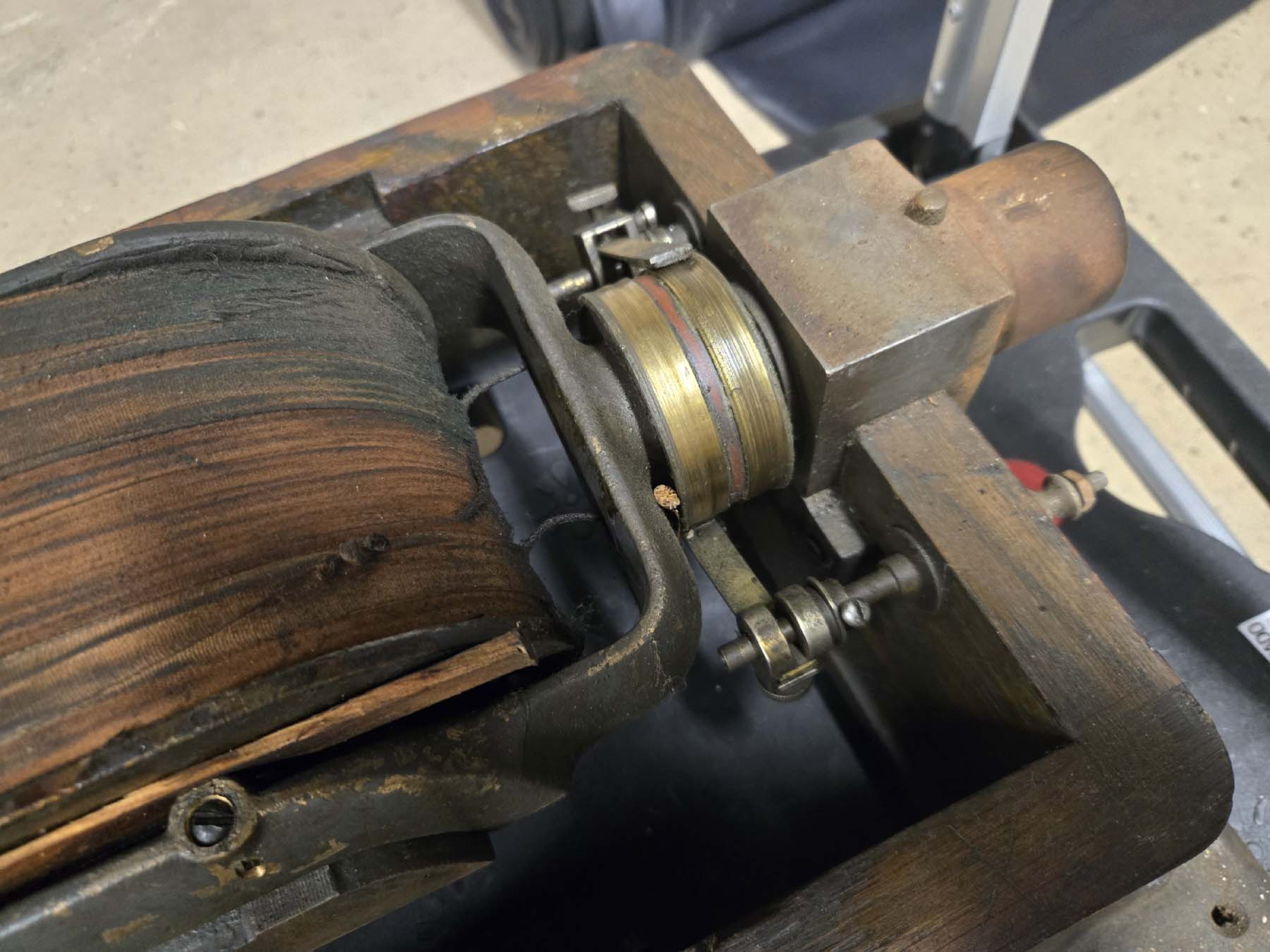

O. S. WALKER Co.
WORCESTER, MASS. U.S.A.

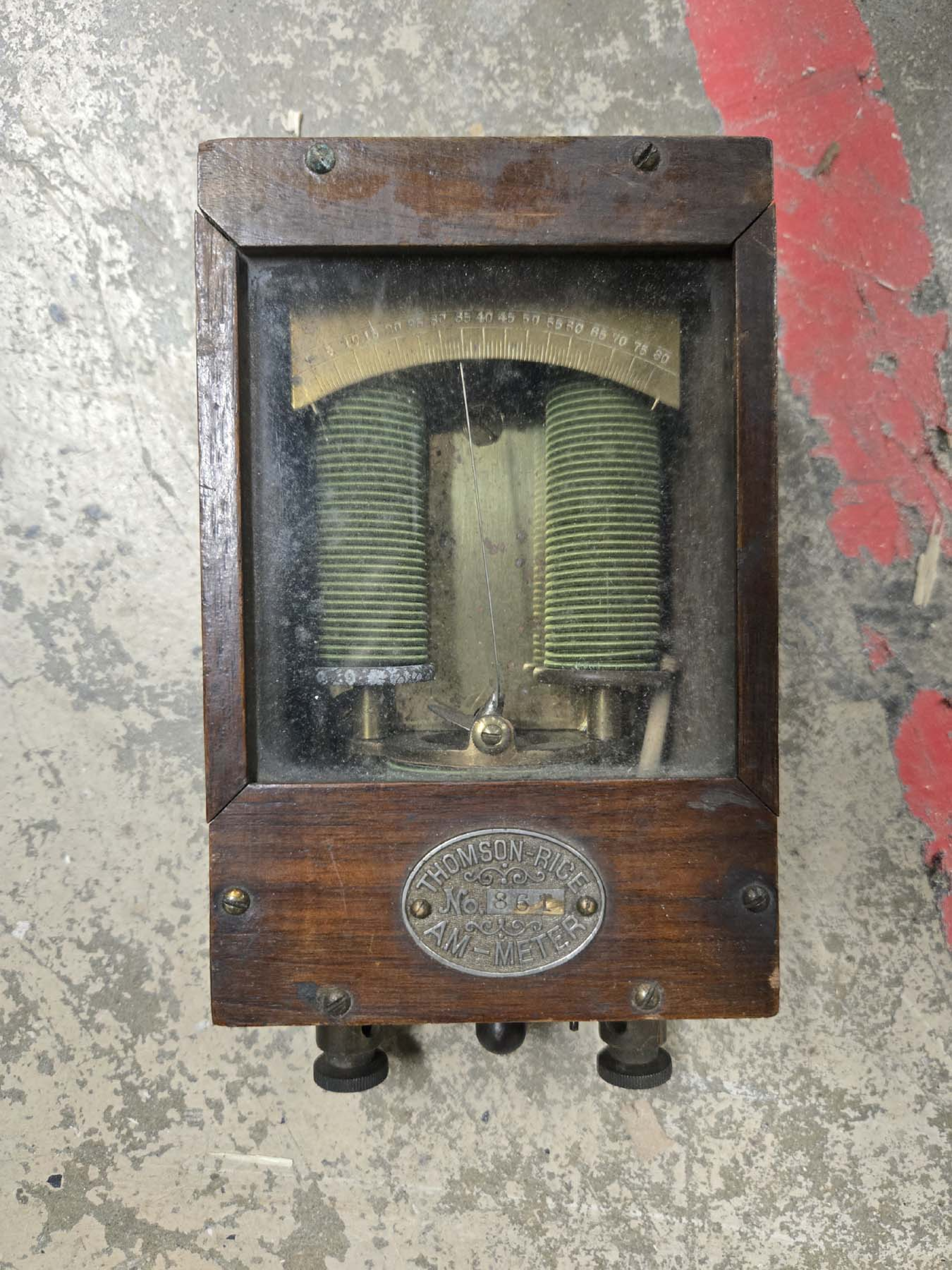

HUSKY
O.S. WALKER CO.
WORCESTER, MASS. U.S.A.


BUILT BY
O.S. WALKER Co.
WORCESTER, MASS. U.S.A.


ABIERTO
CLOSE CERRADO


JOHNSON
ABIERTO
CLOSE CERRADO

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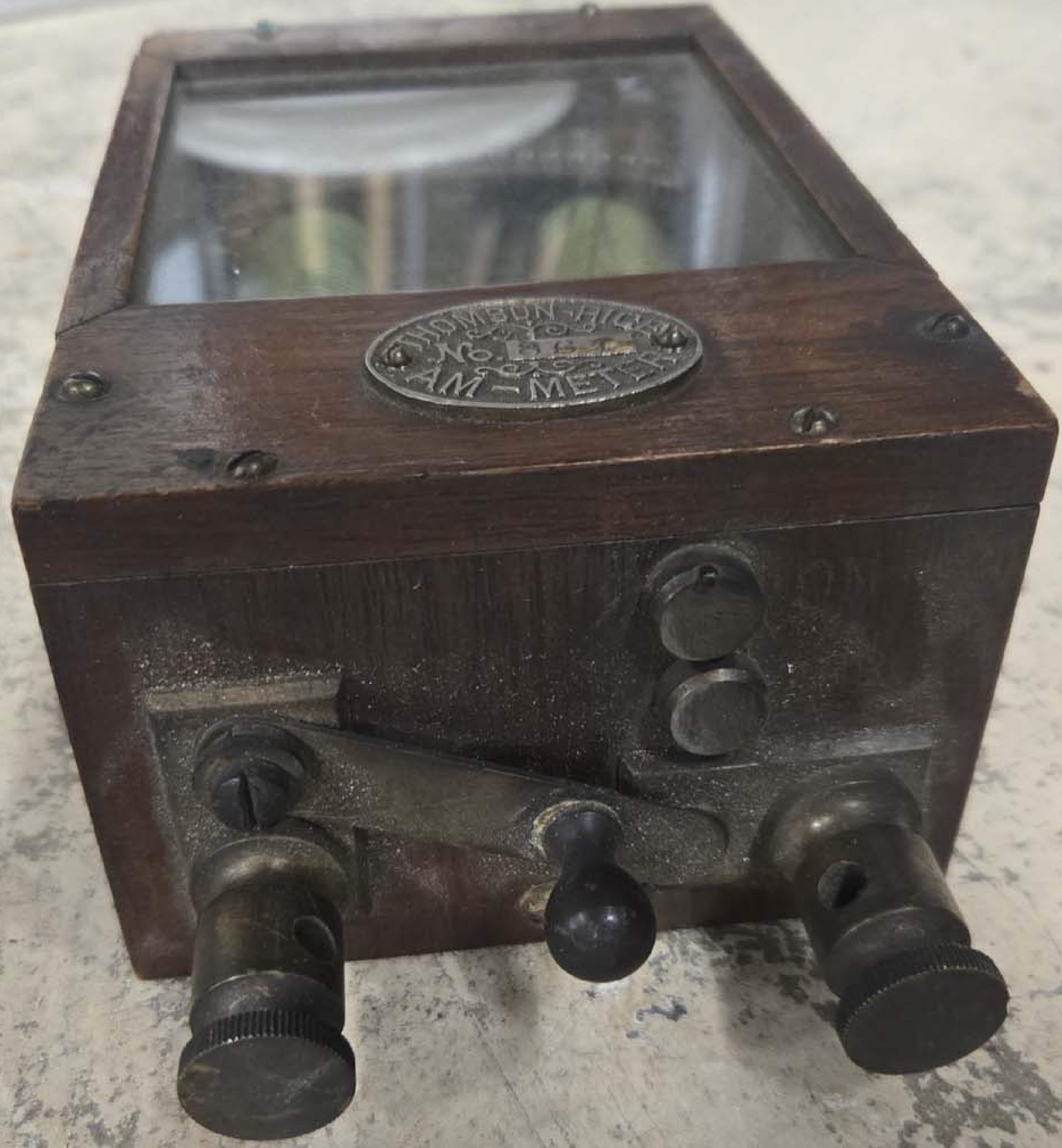
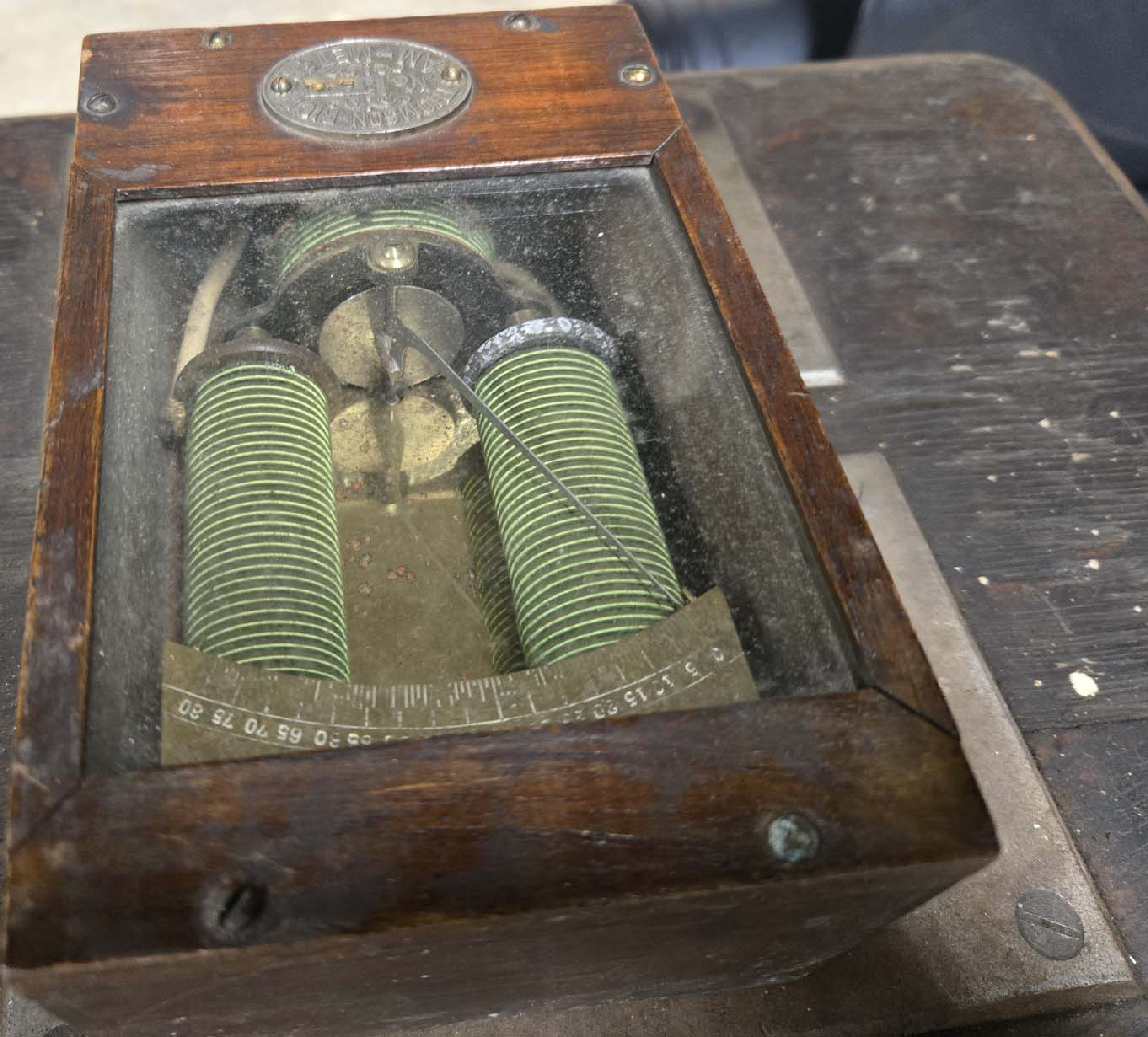
THOMSON-RICE
No. 86
AM-METER


THOMSON
No.
AM-METER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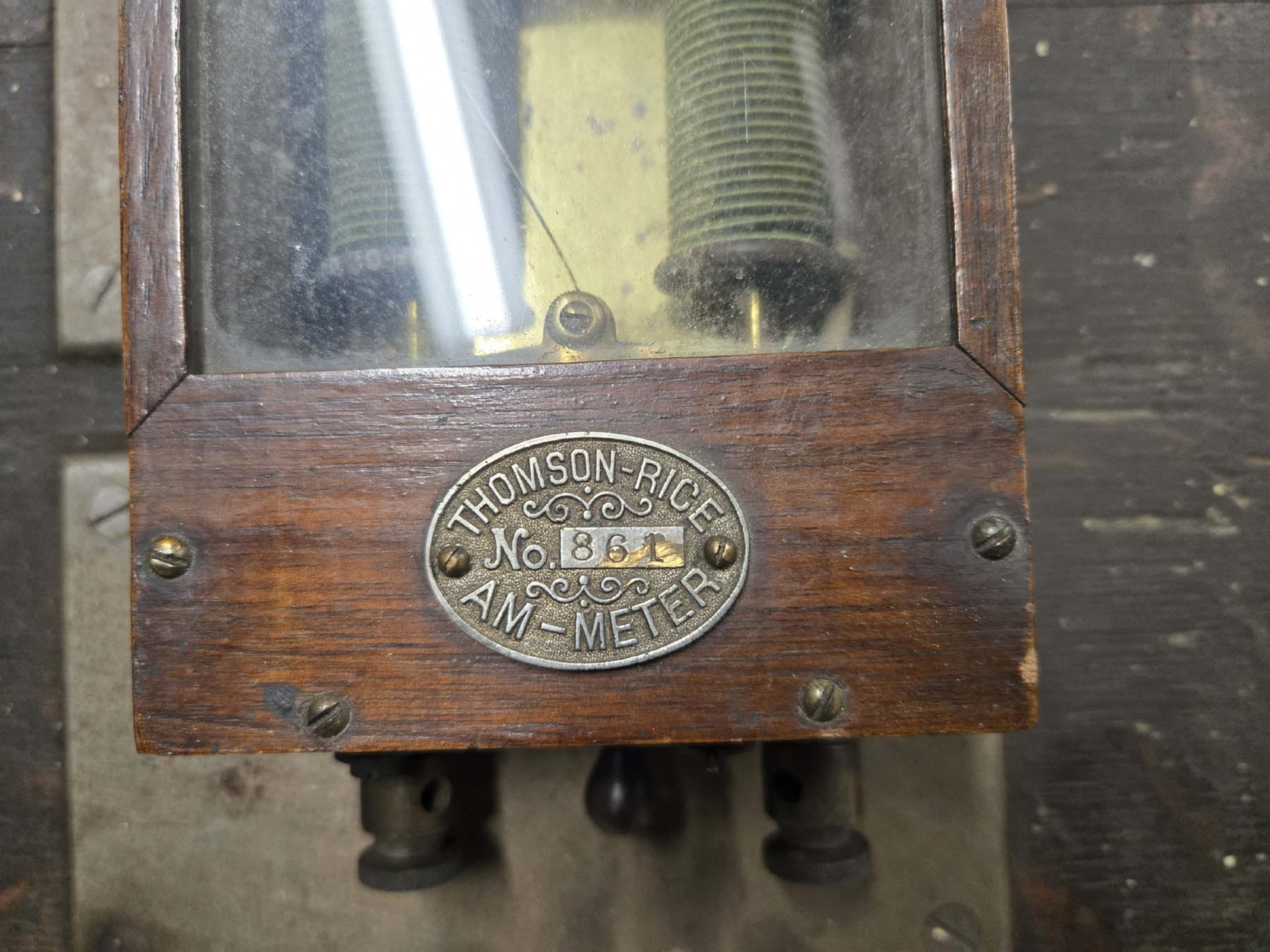
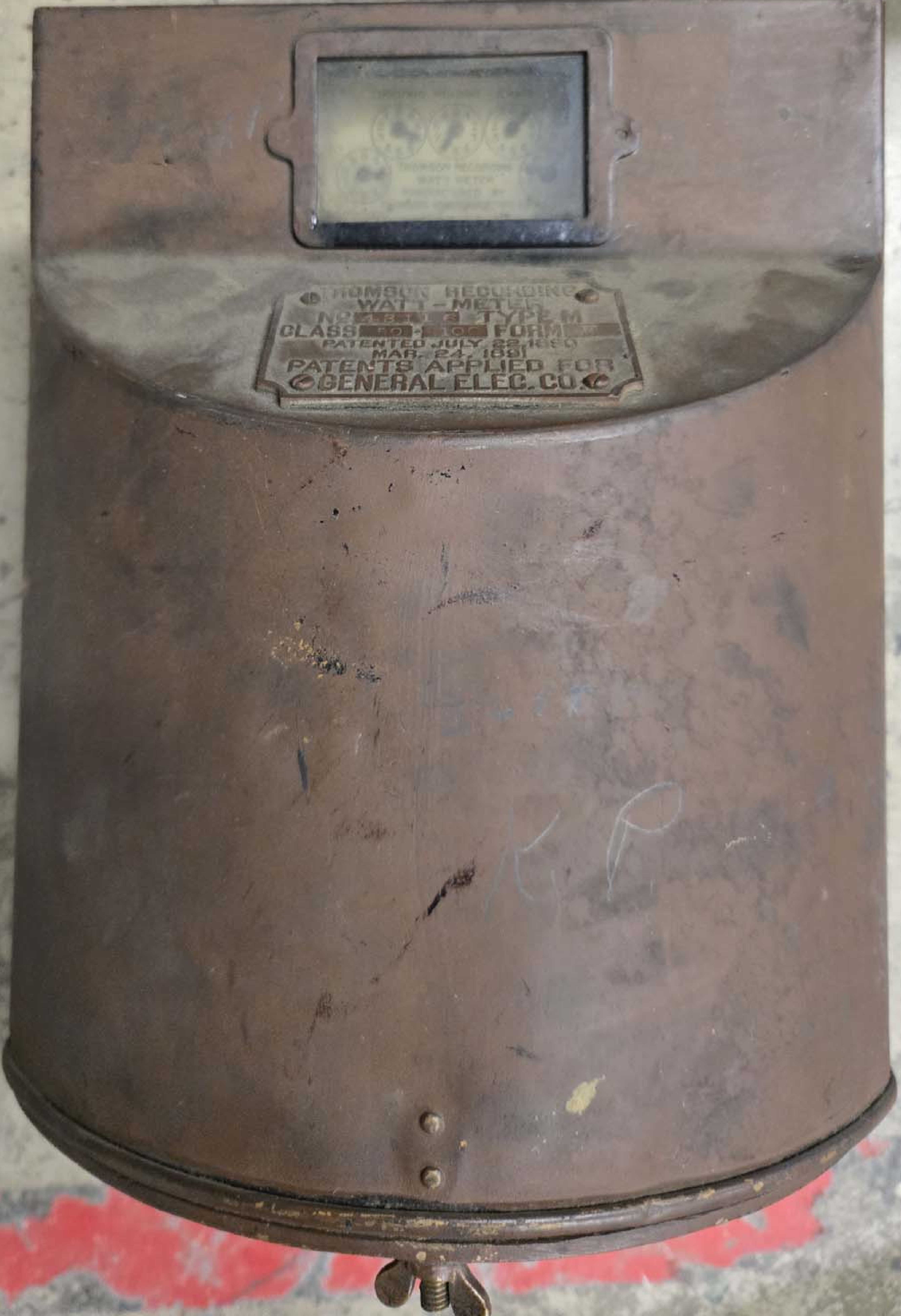
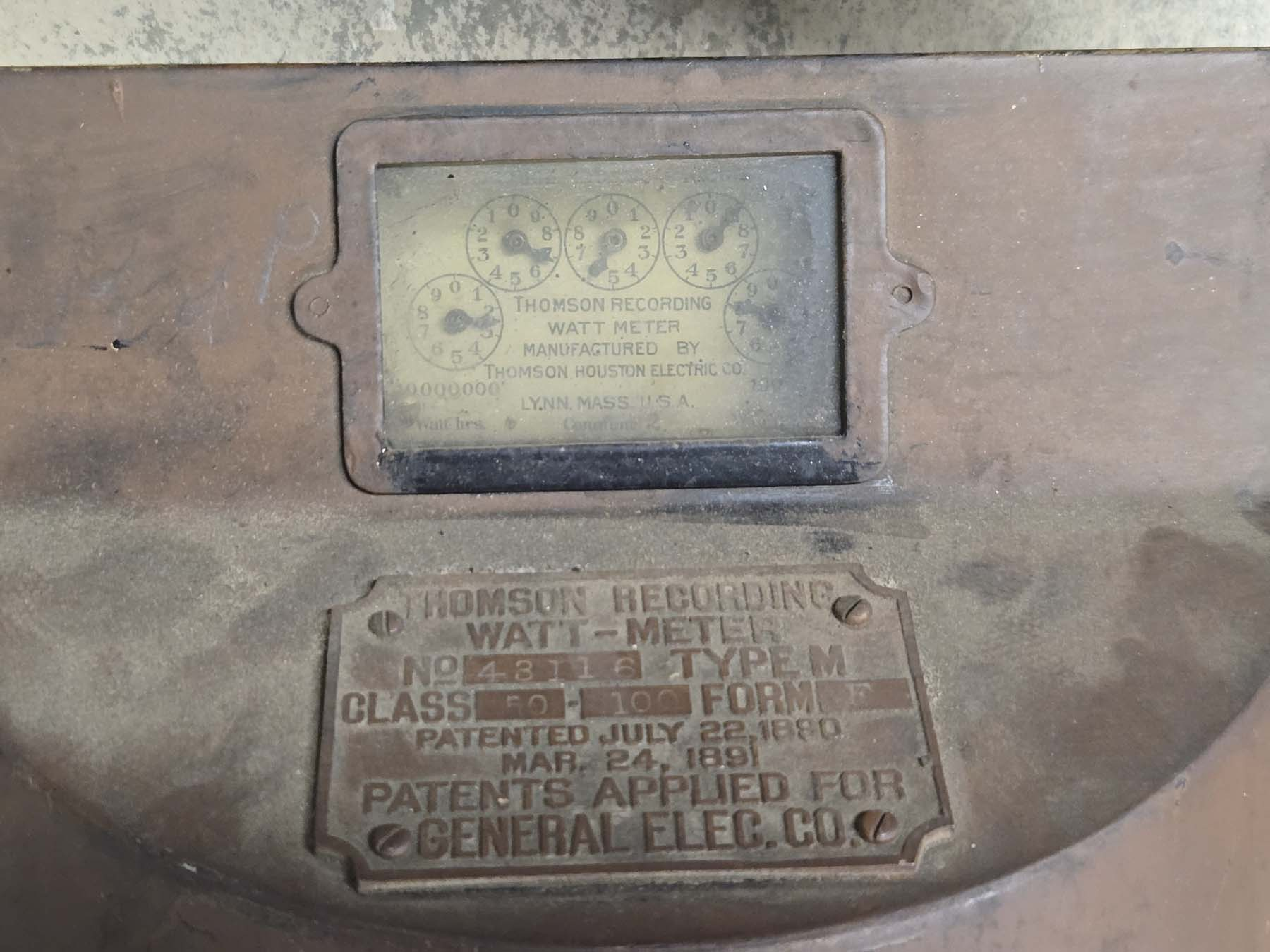
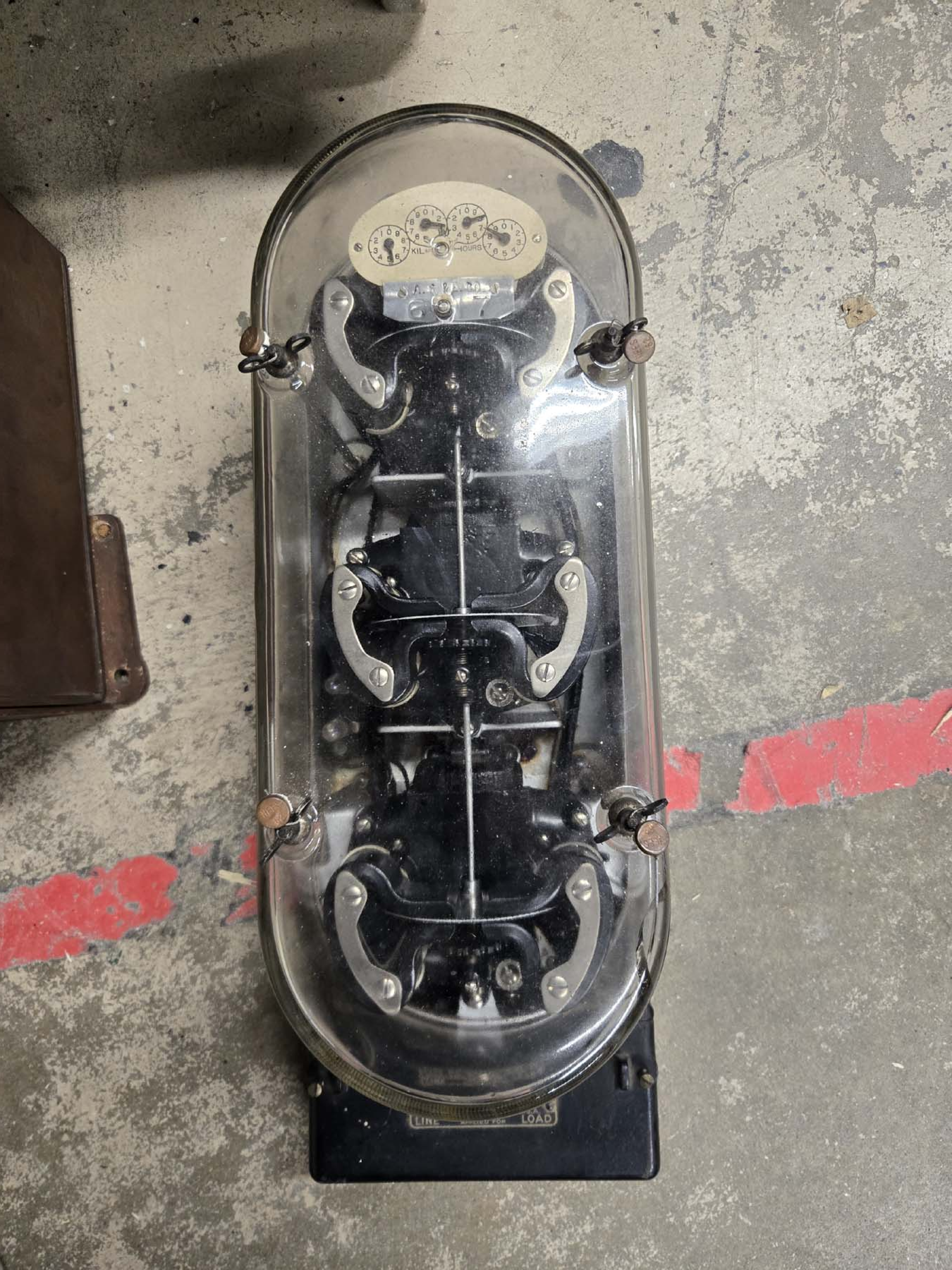
75
80

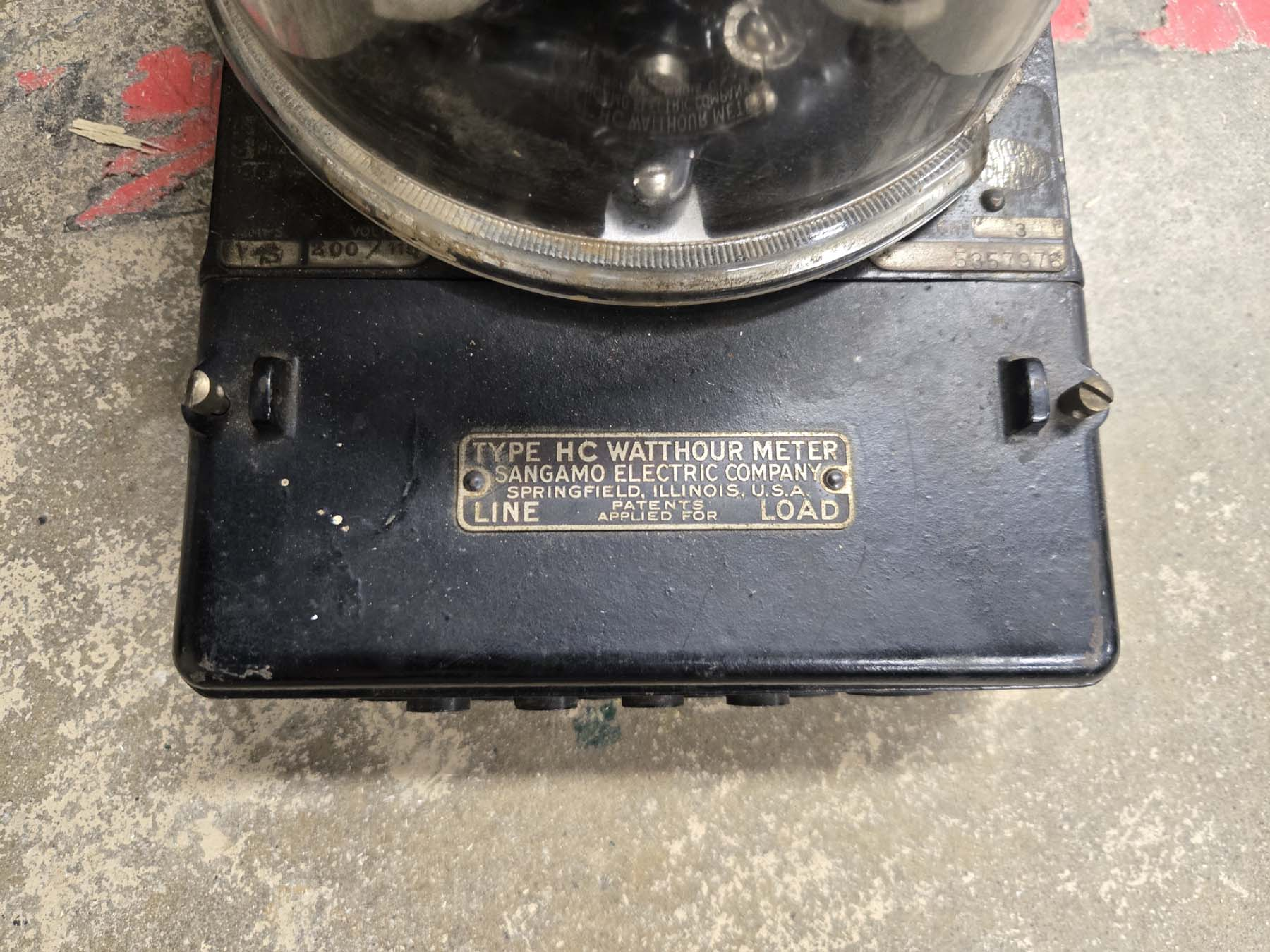

THOMSON-RICE
No. 861
AM-METER

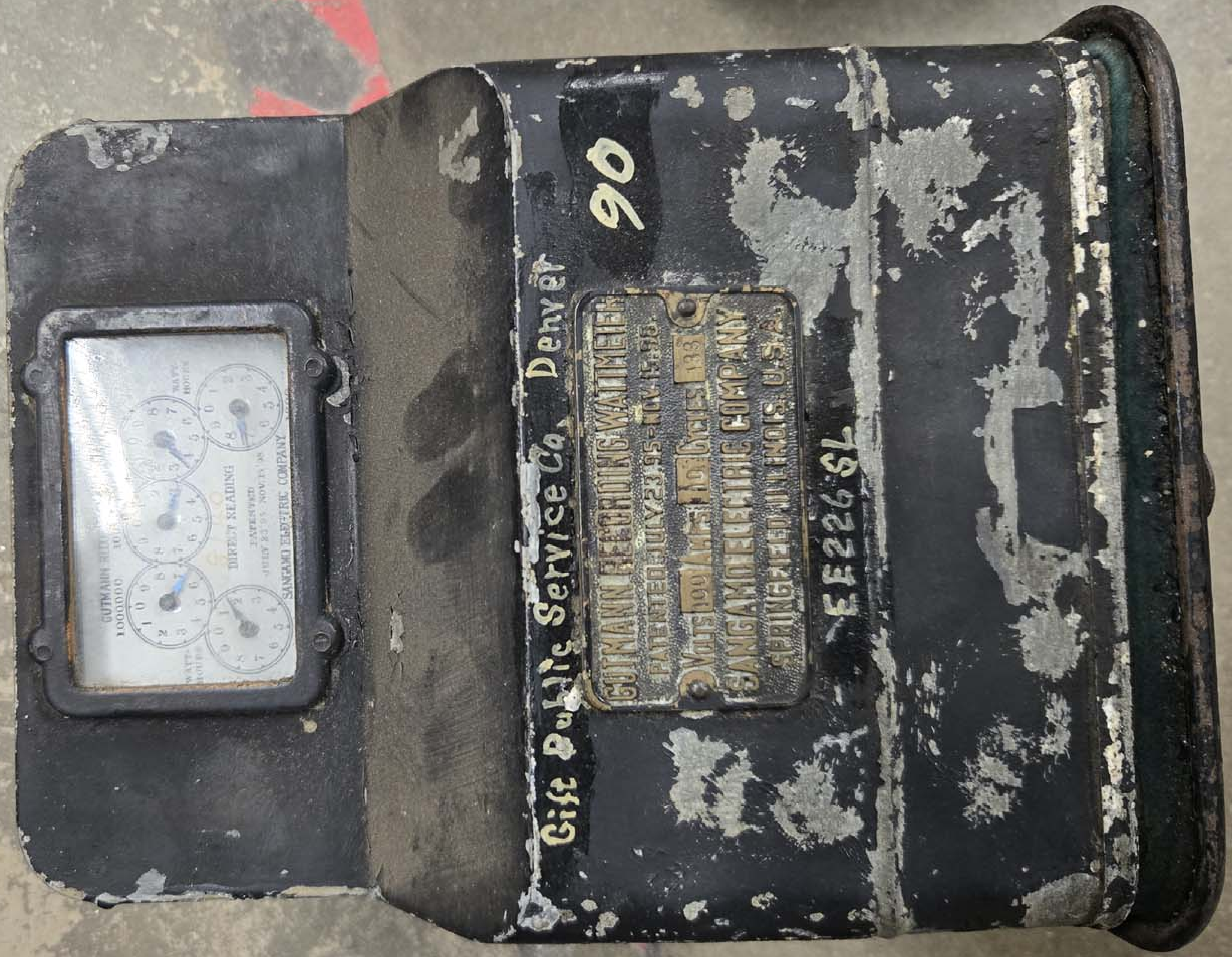

THOMSON RECORDING
WATT-METER
No. TYPE M
CLASS FORM
PATENTED JULY 22, 1890
MAR. 24, 1891
PATENTS APPLIED FOR
GENERAL ELEC. CO.

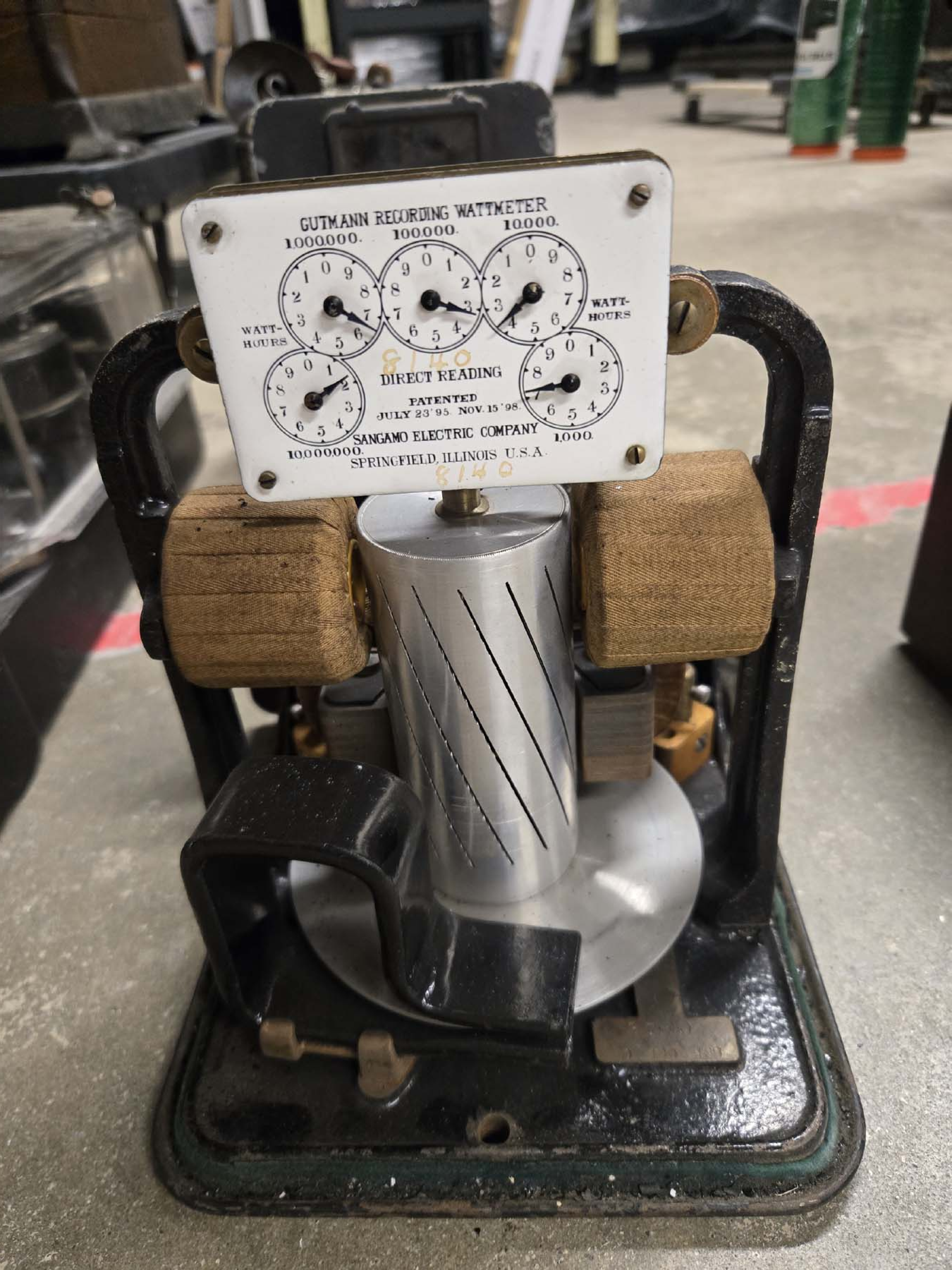

THOMSON RECORDING
WATT METER
MANUFACTURED BY
THOMSON HOUSTON ELECTRIC CO.
LYNN. MASS. U.S.A.
0000000
THOMSON RECORDING
WATT-METER
No 48116 TYPE M
CLASS 50 - 100 FORM E
PATENTED JULY 22, 1880
MAR. 24, 1891
PATENTS APPLIED FOR
GENERAL ELEC. CO.

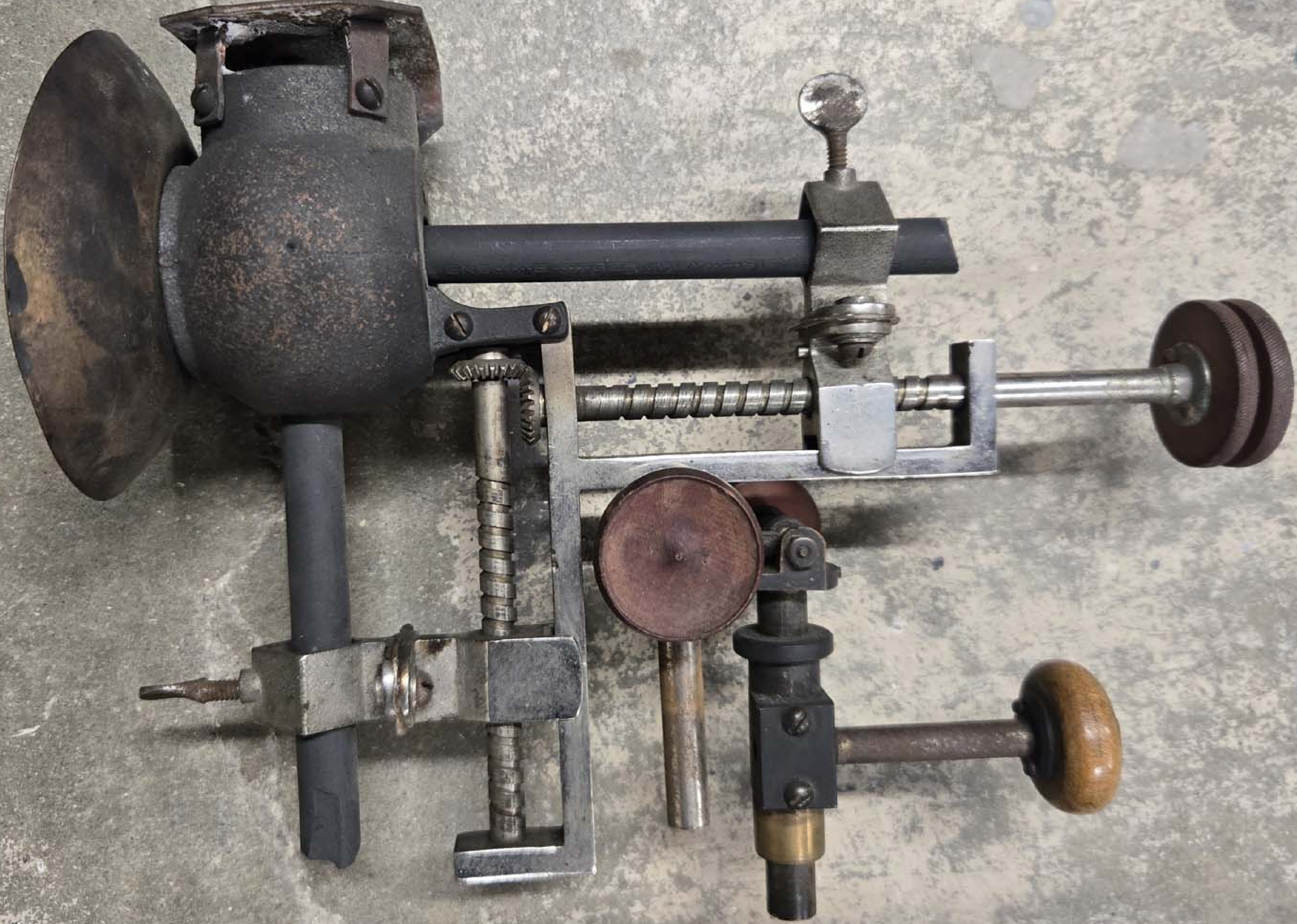

KIL
HOURS
LINE
LOAD

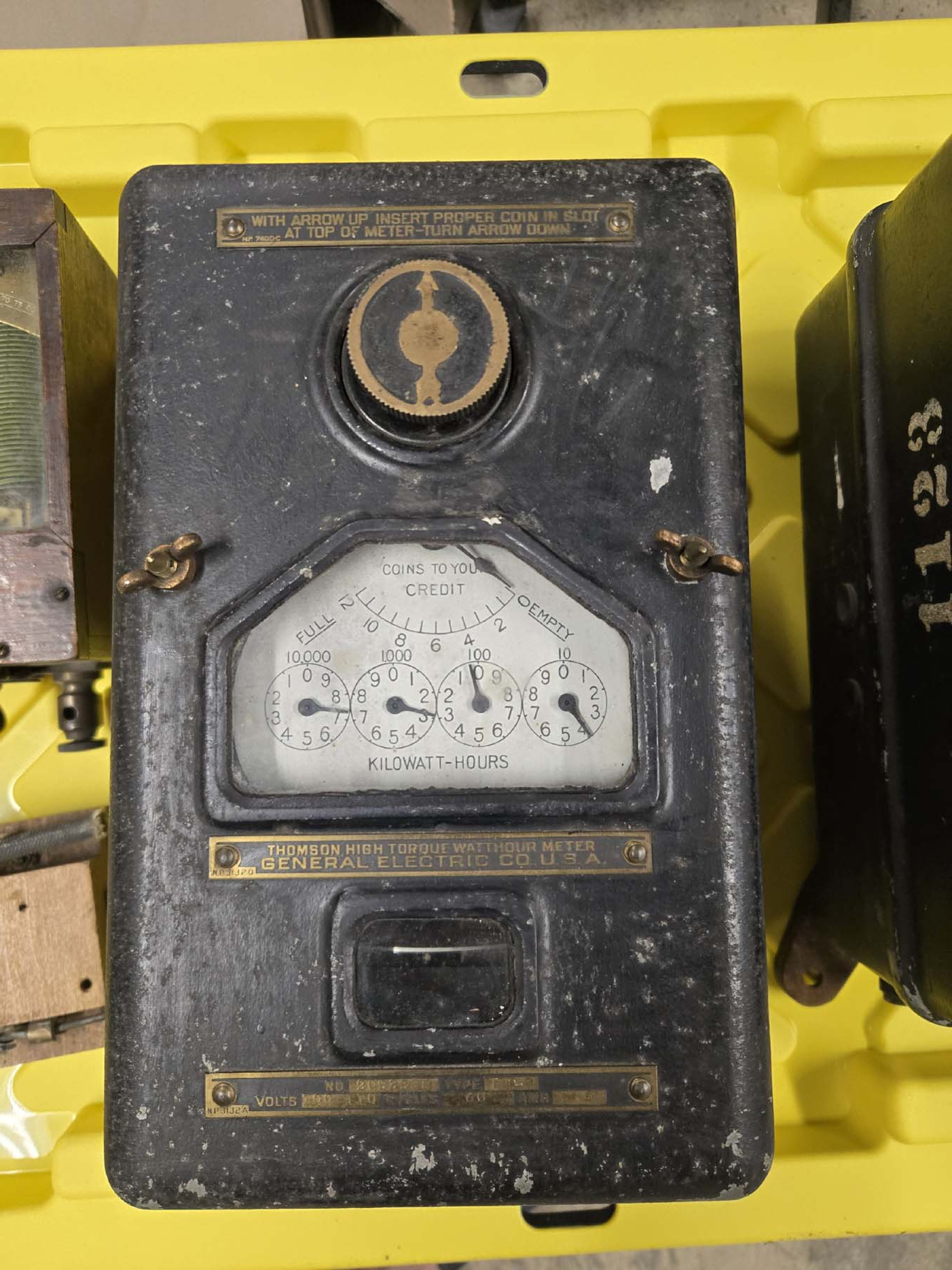
KILOWATT HOURS

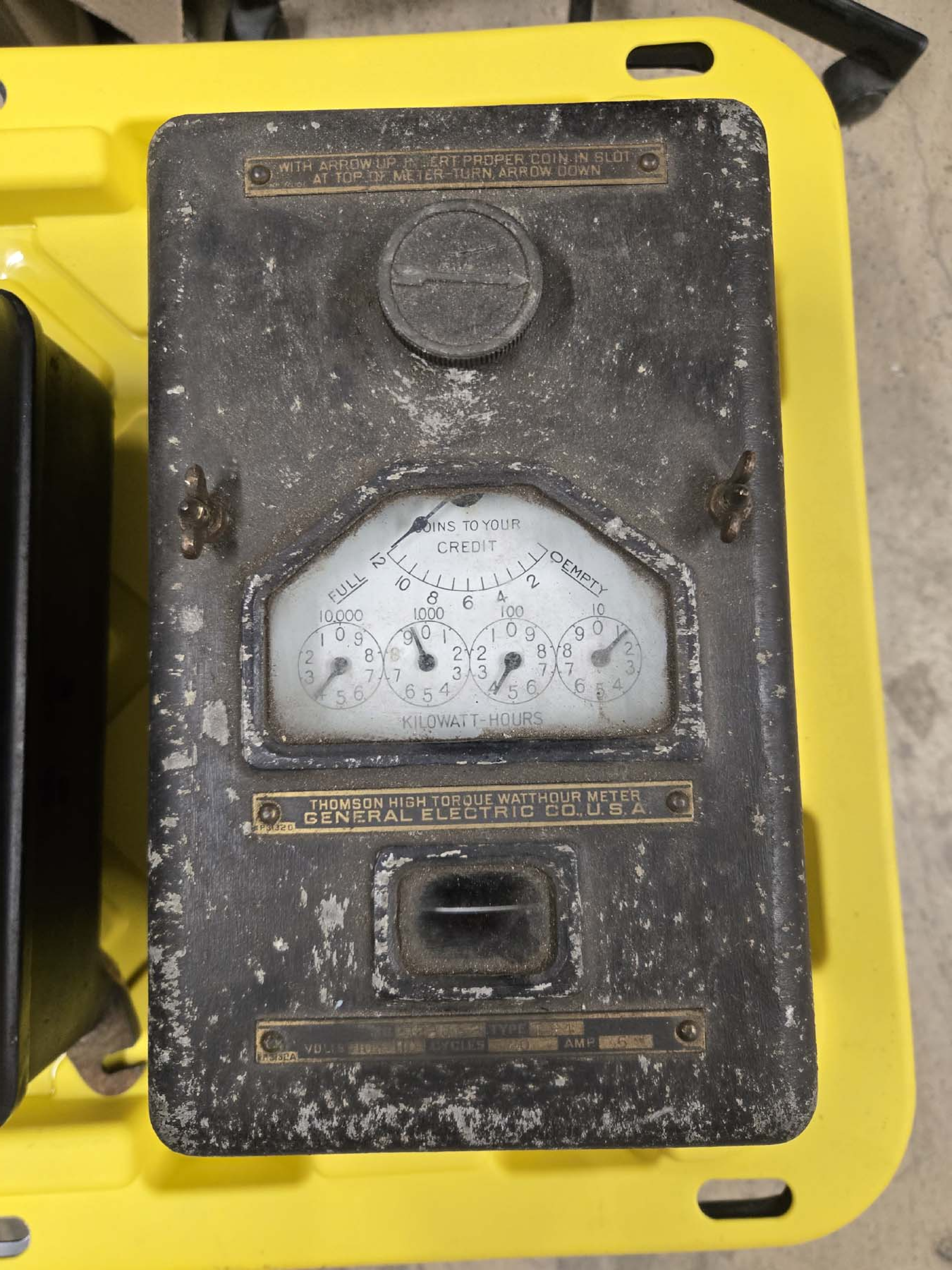

TYPE HC WATTHOUR METER
SANGAMO ELECTRIC COMPANY
SPRINGFIELD, ILLINOIS, U.S.A.
LINE
PATENTS APPLIED FOR
LOAD
3
5357978


Gift Public Service Co. Denver
90
GUTMANN RECORDING WATTMETER
PATENTED JULY 23.95 - NOV. 15.98
VOLTS 100 AMPS 15 CYCLES 133
SANGAMO ELECTRIC COMPANY
SPRINGFIELD ILLINOIS U.S.A.
EE226 SL
GUTMANN
WATT-HOURS
DIRECT READING
PATENTED
SANGAMO ELECTRIC COMPANY

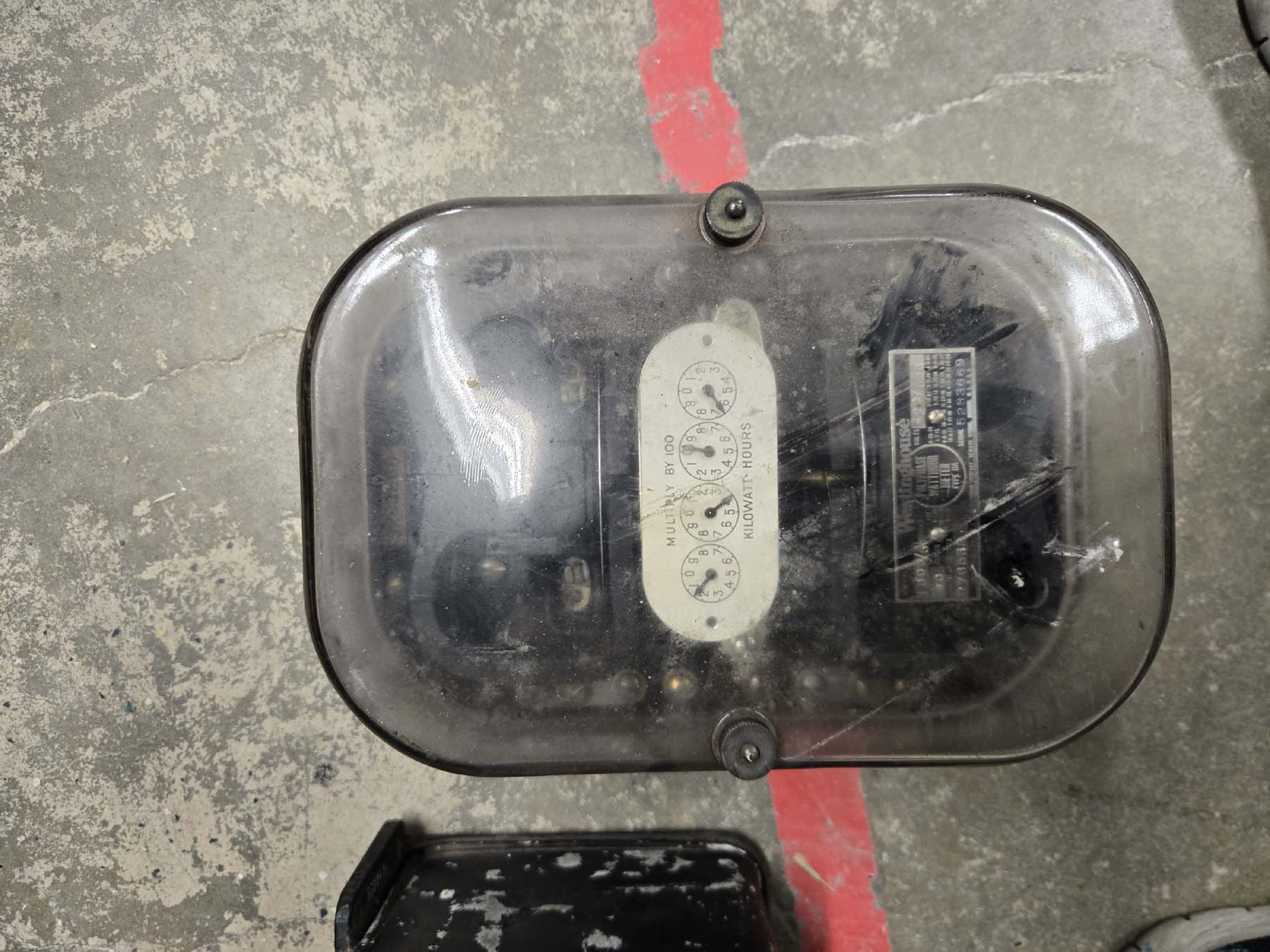

GUTMANN RECORDING WATTMETER
1,000,000.
100,000.
10,000.
WATT-HOURS
WATT-HOURS
8140
DIRECT READING
PATENTED
JULY 23'95. NOV. 15'98.
SANGAMO ELECTRIC COMPANY
10,000,000.
1,000.
SPRINGFIELD, ILLINOIS U.S.A.
8140

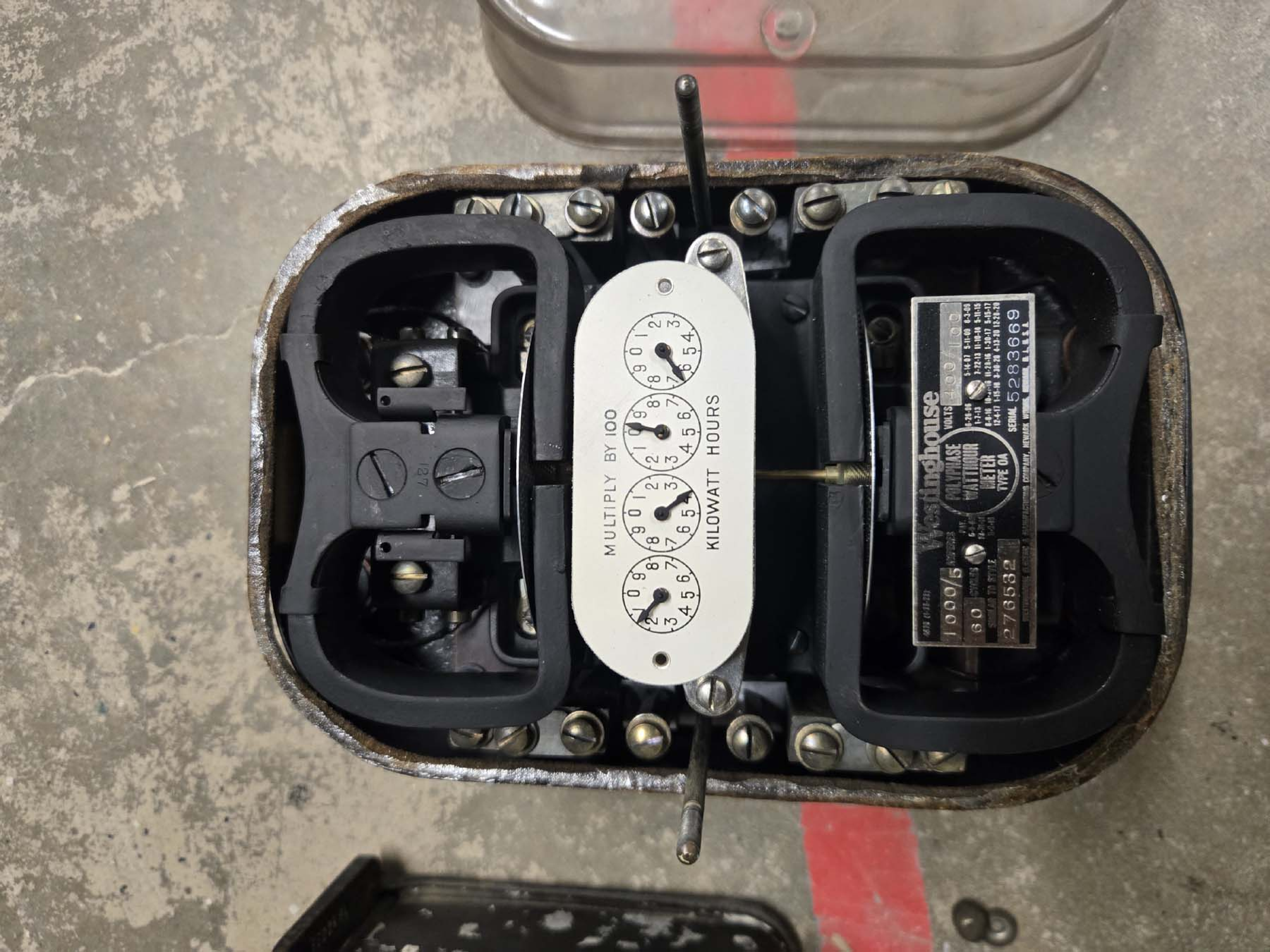


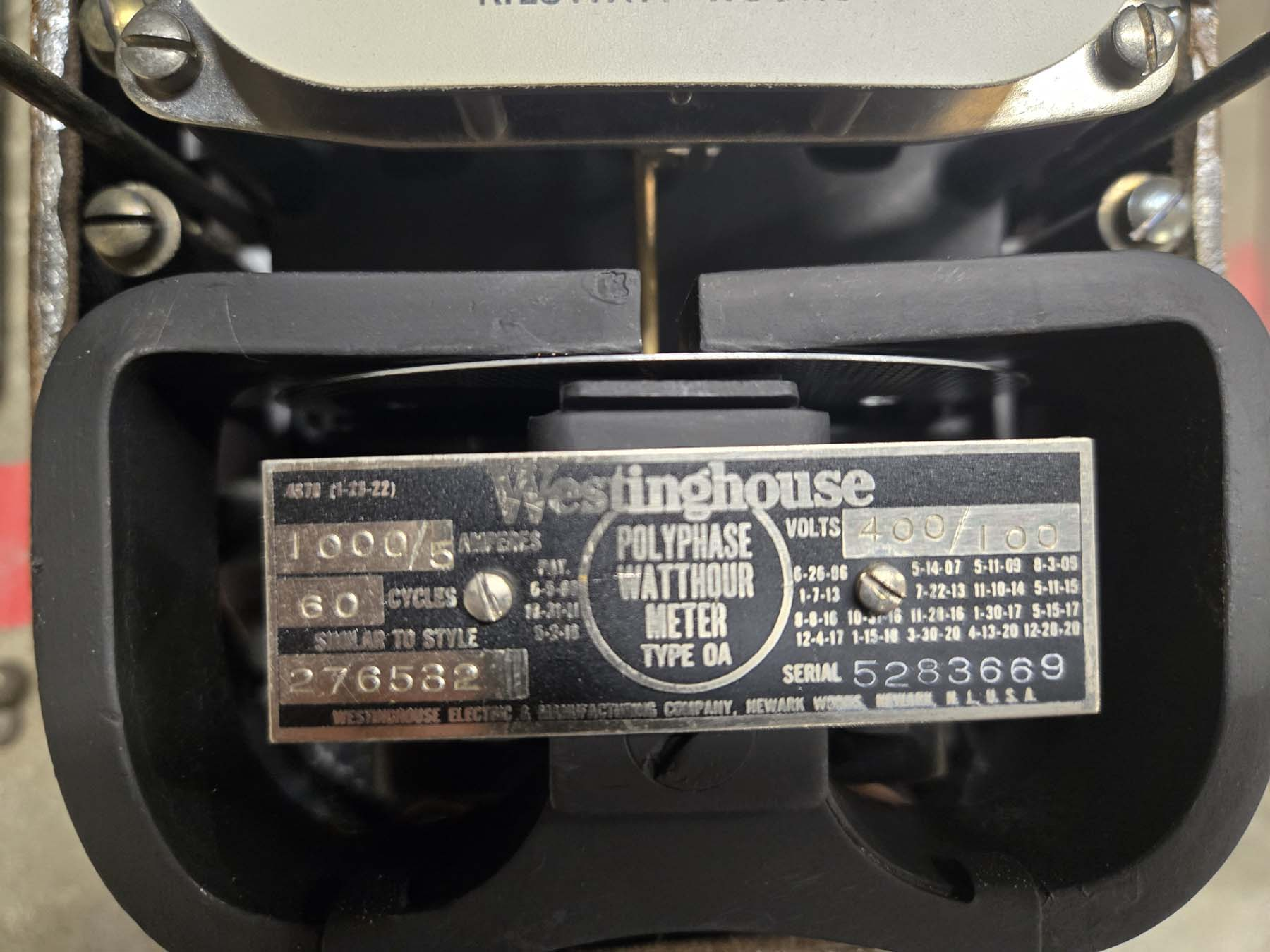

WITH ARROW UP INSERT PROPER COIN IN SLOT
AT TOP OF METER-TURN ARROW DOWN
NP 7400C
COINS TO YOUR
CREDIT
FULL
12
10
8
6
4
2
0
EMPTY
10,000
1000
100
10
KILOWATT-HOURS
THOMSON HIGH TORQUE WATTHOUR METER
GENERAL ELECTRIC CO. U.S.A.
NP3132D
NO
TYPE
VOLTS
CYCLES
60
AMP
NP3132A
1123


WITH ARROW UP INSERT PROPER COIN IN SLOT
AT TOP OF METER-TURN ARROW DOWN
COINS TO YOUR
CREDIT
FULL
12
10
8
6
4
2
0
EMPTY
10,000
1,000
100
10
KILOWATT-HOURS
THOMSON HIGH TORQUE WATTHOUR METER
GENERAL ELECTRIC CO. U.S.A.
TYPE
VOLTS
CYCLES
AMP
5

1123


MULTIPLY BY 100
KILOWATT HOURS
Westinghouse
POLYPHASE
WATTHOUR
METER
TYPE DA
5283669


MULTIPLY BY 100
KILOWATT HOURS
Westinghouse
POLYPHASE WATTHOUR METER TYPE OA
VOLTS 400/100
SERIAL 52833669
1000/5
60
276532
U.S.A.



4370 (1-25-22)

Westinghouse

1000/5 AMPERES

60 CYCLES

SIMILAR TO STYLE

276532

PAT.
6-5-06
10-31-11
5-2-16

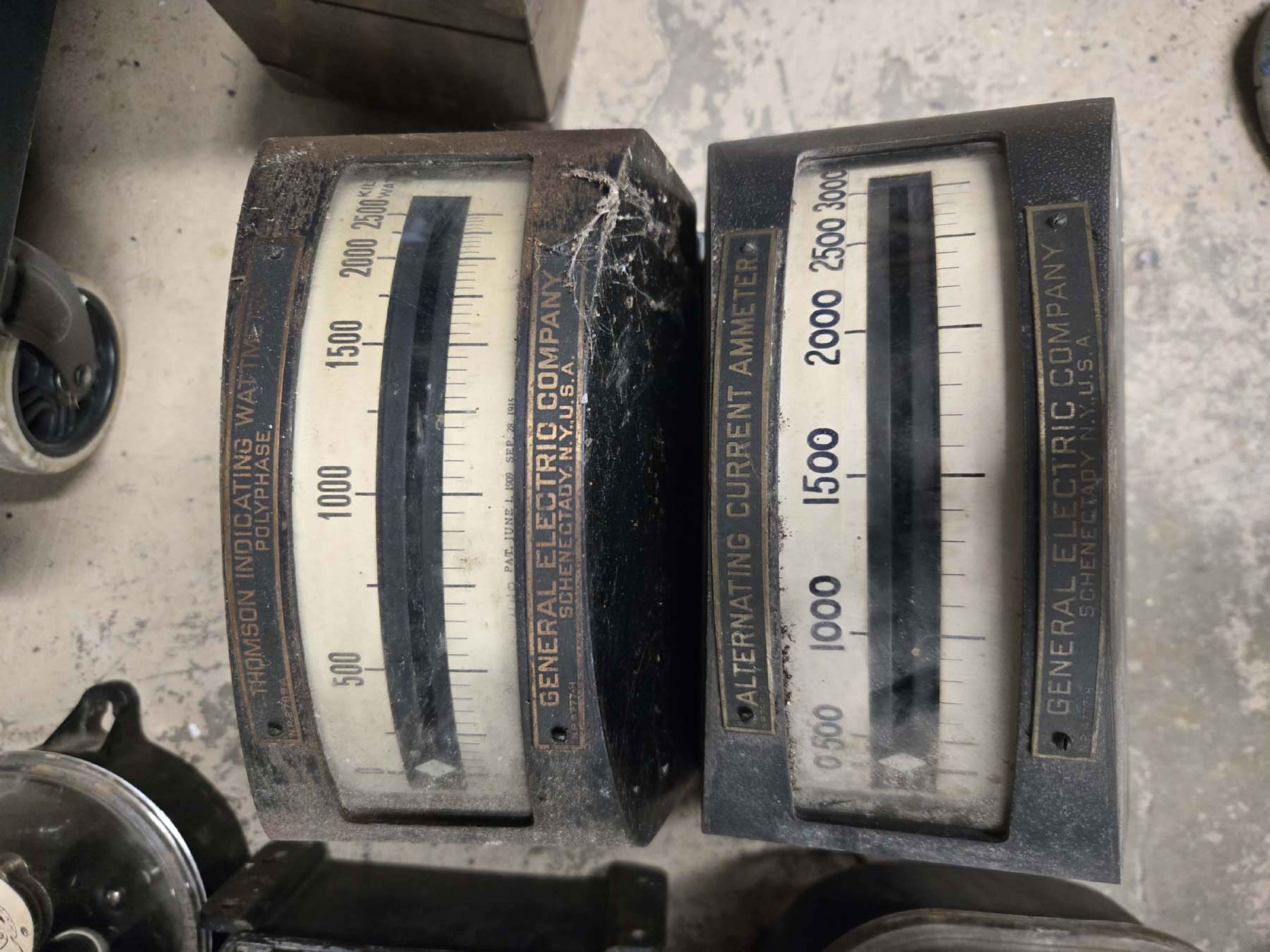
POLYPHASE
WATTHOUR
METER
TYPE OA

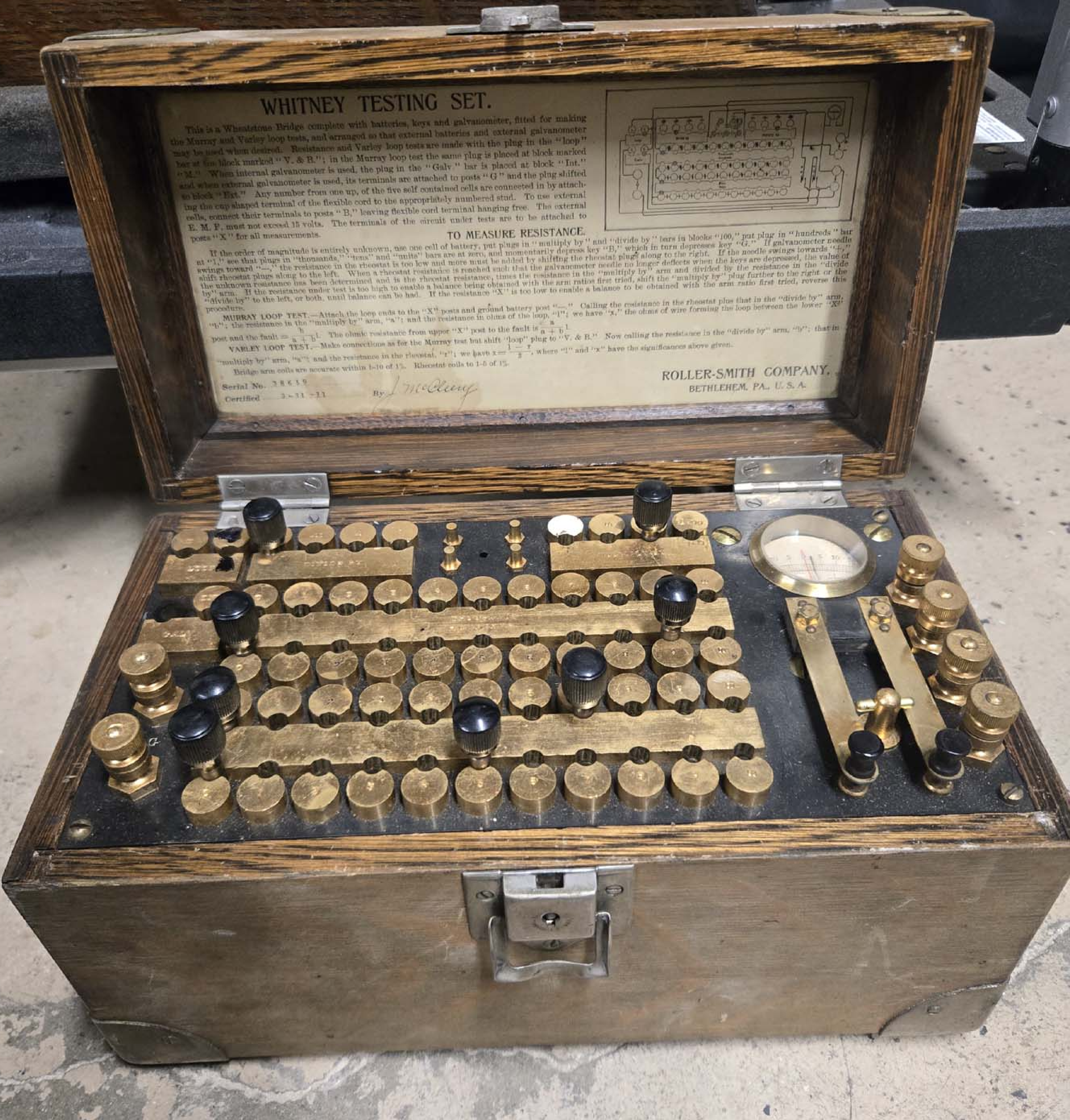
VOLTS 400/100

6-26-06 5-14-07 5-11-09 8-3-09
1-7-13 7-22-13 11-10-14 5-11-15
8-8-16 10-31-16 11-28-16 1-30-17 5-15-17
12-4-17 1-15-18 3-30-20 4-13-20 12-28-20

SERIAL 5283669

WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY, NEWARK WORKS, NEWARK, N. J. U. S. A.


THOMSON INDICATING WATTMET
POLYPHASE
500
1000
1500
2000
2500 KIL WAT
PAT. JUNE 1, 1909 SEP. 28, 1915
GENERAL ELECTRIC COMPANY
SCHENECTADY, N.Y., U.S.A.
ALTERNATING CURRENT AMMETER
0
500
1000
1500
2000
2500
3000
GENERAL ELECTRIC COMPANY
SCHENECTADY N.Y., U.S.A.



WHITNEY TESTING SET.

This is a Wheatstone Bridge complete with batteries, keys and galvanometer, fitted for making the Murray and Varley loop tests, and arranged so that external batteries and external galvanometer may be used when desired. Resistance and Varley loop tests are made with the plug in the "loop" bar at the block marked "V. & B."; in the Murray loop test the same plug is placed at block marked "M." When internal galvanometer is used, the plug in the "Galv" bar is placed at block "Int." and when external galvanometer is used, its terminals are attached to posts "G" and the plug shifted to block "Ext." Any number from one up, of the five self contained cells are connected in by attaching the cup shaped terminal of the flexible cord to the appropriately numbered stud. To use external cells, connect their terminals to posts "B," leaving flexible cord terminal hanging free. The external E. M. F. must not exceed 15 volts. The terminals of the circuit under tests are to be attached to posts "X" for all measurements.

TO MEASURE RESISTANCE.

If the order of magnitude is entirely unknown, use one cell of battery, put plugs in "multiply by" and "divide by" bars in blocks "100," put plug in "hundreds" bar at "1," see that plugs in "thousands," "tens" and "units" bars are at zero, and momentarily depress key "B," which in turn depresses key "G." If galvanometer needle swings toward "—," the resistance in the rheostat is too low and more must be added by shifting the rheostat plugs along to the right. If the needle swings towards "+," shift rheostat plugs along to the left. When a rheostat resistance is reached such that the galvanometer needle no longer deflects when the keys are depressed, the value of the unknown resistance has been determined and is the rheostat resistance, times the resistance in the "multiply by" arm and divided by the resistance in the "divide by" arm. If the resistance under test is too high to enable a balance being obtained with the arm ratios first tried, shift the "multiply by" plug further to the right or the "divide by" to the left, or both, until balance can be had. If the resistance "X" is too low to enable a balance to be obtained with the arm ratio first tried, reverse this procedure.

MURRAY LOOP TEST.—Attach the loop ends to the "X" posts and ground battery post "—." Calling the resistance in the rheostat plus that in the "divide by" arm, "b"; the resistance in the "multiply by" arm, "a"; and the resistance in ohms of the loop, "l"; we have "x," the ohms of wire forming the loop between the lower "X" post and the fault $= \frac{b}{a+b}l$. The ohmic resistance from upper "X" post to the fault is $\frac{a}{a+b}l$.

VARLEY LOOP TEST.—Make connections as for the Murray test but shift "loop" plug to "V. & B." Now calling the resistance in the "divide by" arm, "b"; that in "multiply by" arm, "a"; and the resistance in the rheostat, "r"; we have $x = \frac{l-r}{2}$, where "l" and "x" have the significances above given.

Bridge arm coils are accurate within 1-10 of 1%. Rheostat coils to 1-5 of 1%.

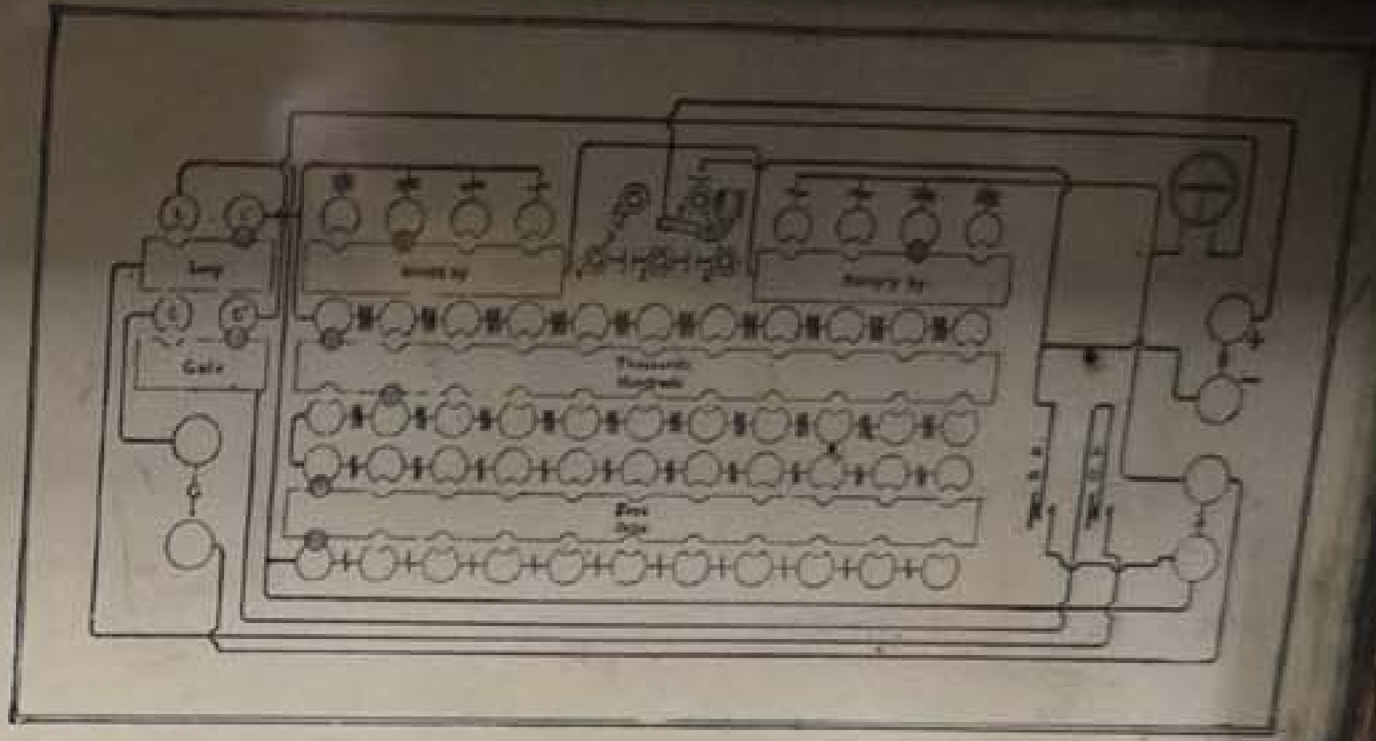
Serial No. 28659

Certified 3-31-11 By J McClury

ROLLER-SMITH COMPANY,
BETHLEHEM, PA., U. S. A.

WHITNEY TESTING SET.

This is a Wheatstone Bridge complete with batteries, keys and galvanometer, fitted for making the Murray and Varley loop tests, and arranged so that external batteries and external galvanometer may be used when desired. Resistance and Varley loop tests are made with the plug in the "loop" bar at the block marked "V. & B."; in the Murray loop test the same plug is placed at block marked "M." When internal galvanometer is used, the plug in the "Galv." bar is placed at block "Int." and when external galvanometer is used, its terminals are attached to posts "G" and the plug shifted to block "Ext." Any number from one up, of the five self contained cells are connected in by attaching the cup shaped terminal of the flexible cord to the appropriately numbered stud. To use external cells, connect their terminals to posts "B," leaving flexible cord terminal hanging free. The external E. M. F. must not exceed 15 volts. The terminals of the circuit under tests are to be attached to posts "X" for all measurements.



TO MEASURE RESISTANCE.

If the order of magnitude is entirely unknown, use one cell of battery, put plugs in "multiply by" and "divide by" bars in blocks "100," put plug in "hundreds" bar at "1," see that plugs in "thousands," "tens" and "units" bars are at zero, and momentarily depress key "B," which in turn depresses key "G." If galvanometer needle swings toward "—," the resistance in the rheostat is too low and more must be added by shifting the rheostat plugs along to the right. If the needle swings towards "+," shift rheostat plugs along to the left. When a rheostat resistance is reached such that the galvanometer needle no longer deflects when the keys are depressed, the value of the unknown resistance has been determined and is the rheostat resistance, times the resistance in the "multiply by" arm and divided by the resistance in the "divide by" arm. If the resistance under test is too high to enable a balance being obtained with the arm ratios first tried, shift the "multiply by" plug further to the right or the "divide by" to the left, or both, until balance can be had. If the resistance "X" is too low to enable a balance to be obtained with the arm ratio first tried, reverse this procedure.

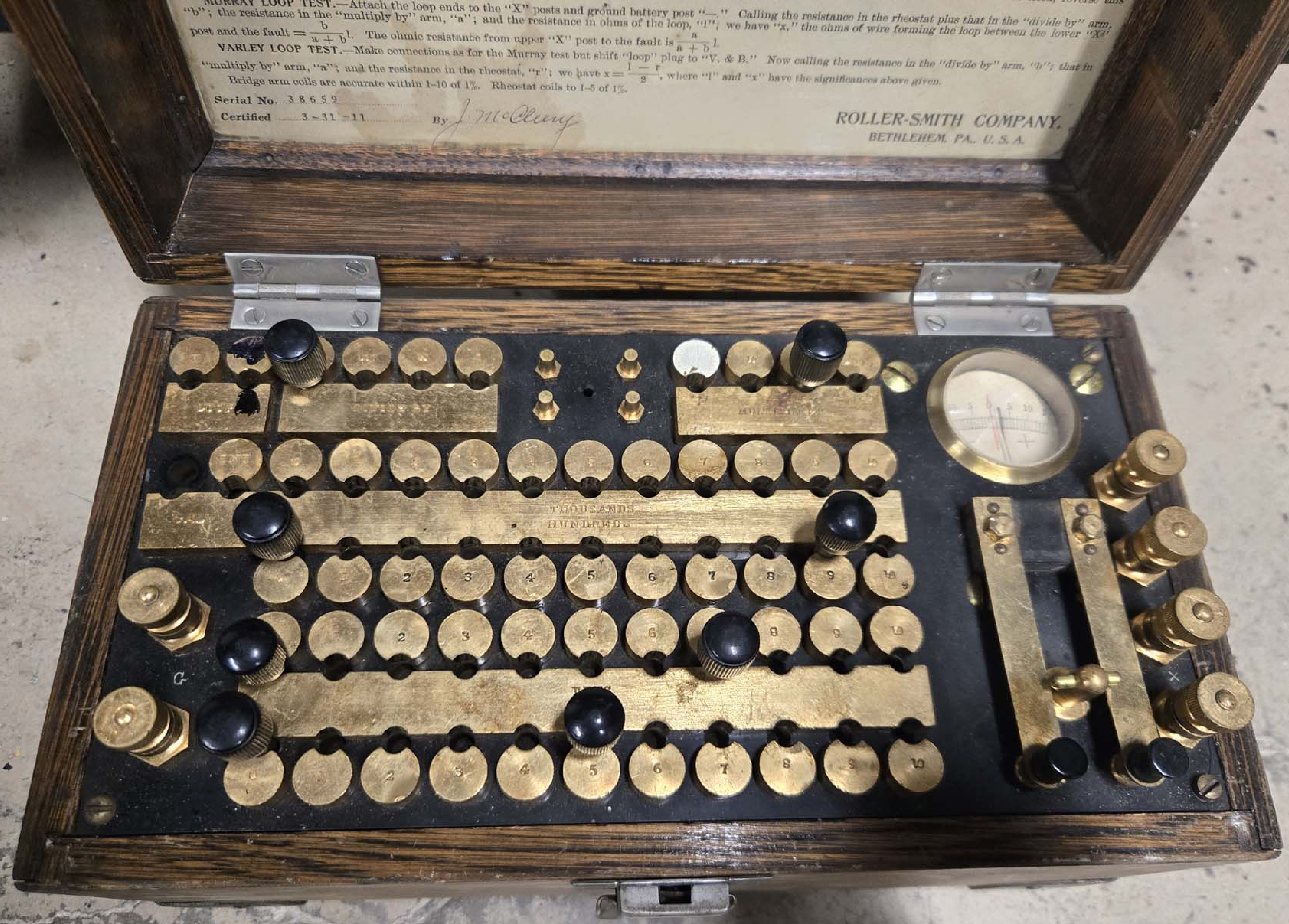
MURRAY LOOP TEST.—Attach the loop ends to the "X" posts and ground battery post "—." Calling the resistance in the rheostat plus that in the "divide by" arm, "b"; the resistance in the "multiply by" arm, "a"; and the resistance in ohms of the loop, "l"; we have "x," the ohms of wire forming the loop between the lower "X" post and the fault $= \frac{b}{a+b} l$. The ohmic resistance from upper "X" post to the fault is $\frac{a}{a+b} l$.

VARLEY LOOP TEST.—Make connections as for the Murray test but shift "loop" plug to "V. & B." Now calling the resistance in the "divide by" arm, "b"; that in "multiply by" arm, "a"; and the resistance in the rheostat, "r"; we have $x = \frac{l-r}{2}$, where "l" and "x" have the significances above given.

Bridge arm coils are accurate within 1-10 of 1%. Rheostat coils to 1-5 of 1%.

Serial No. 38659
Certified 3-31-11 By J. McClung

ROLLER-SMITH COMPANY.
BETHLEHEM, PA., U. S. A.



MURRAY LOOP TEST.—Attach the loop ends to the "X" posts and ground battery post "—." Calling the resistance in the rheostat plus that in the "divide by" arm, "b"; the resistance in the "multiply by" arm, "a"; and the resistance in ohms of the loop, "l"; we have "x," the ohms of wire forming the loop between the lower "X" post and the fault $= \frac{b}{a + b} l$. The ohmic resistance from upper "X" post to the fault is $\frac{a}{a + b} l$.

VARLEY LOOP TEST.—Make connections as for the Murray test but shift "loop" plug to "V. & B." Now calling the resistance in the "divide by" arm, "b"; that in "multiply by" arm, "a"; and the resistance in the rheostat, "r"; we have $x = \frac{l - r}{2}$, where "l" and "x" have the significances above given.

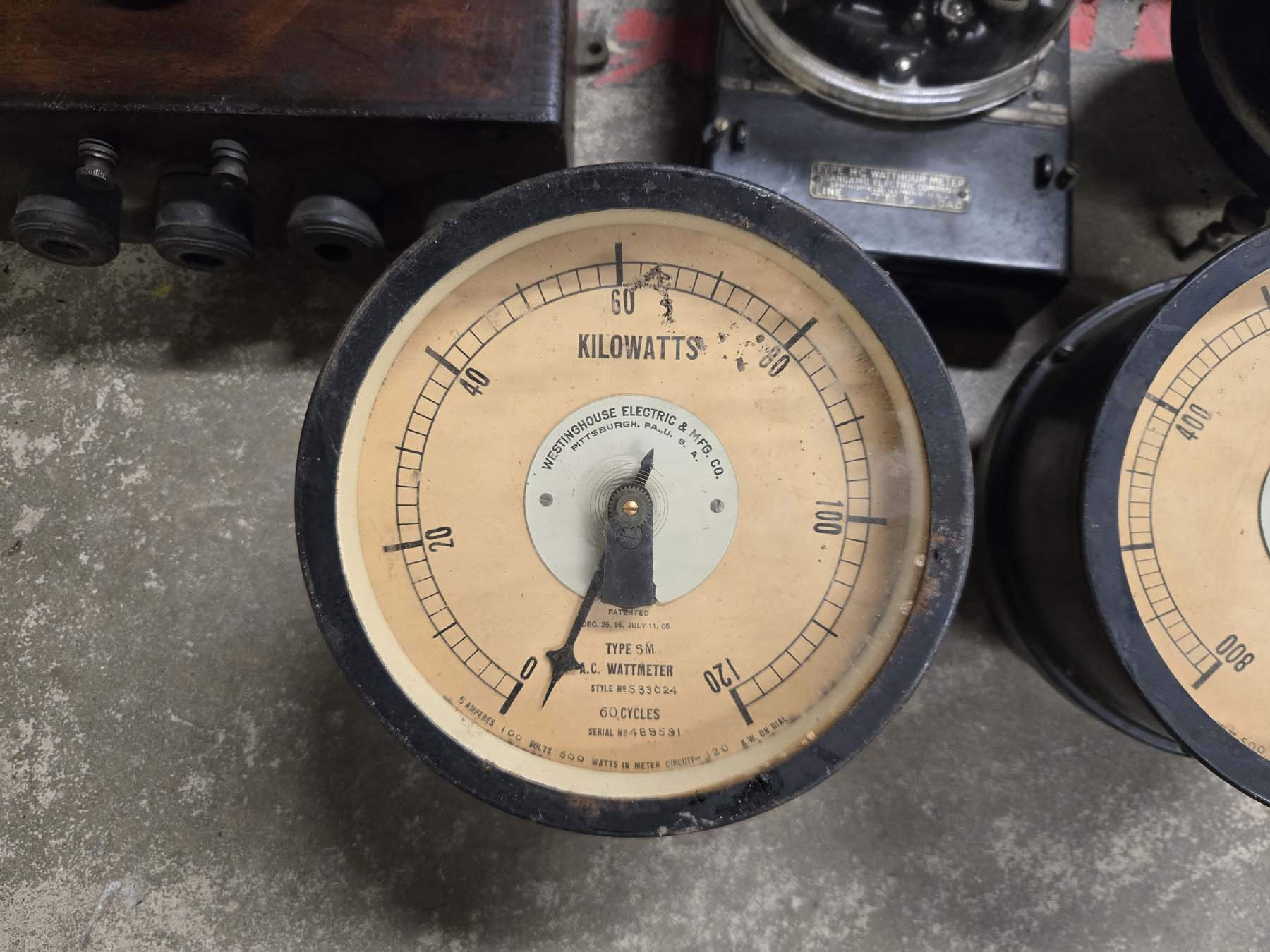
Bridge arm coils are accurate within 1-10 of 1%. Rheostat coils to 1-5 of 1%.

Serial No. 38659

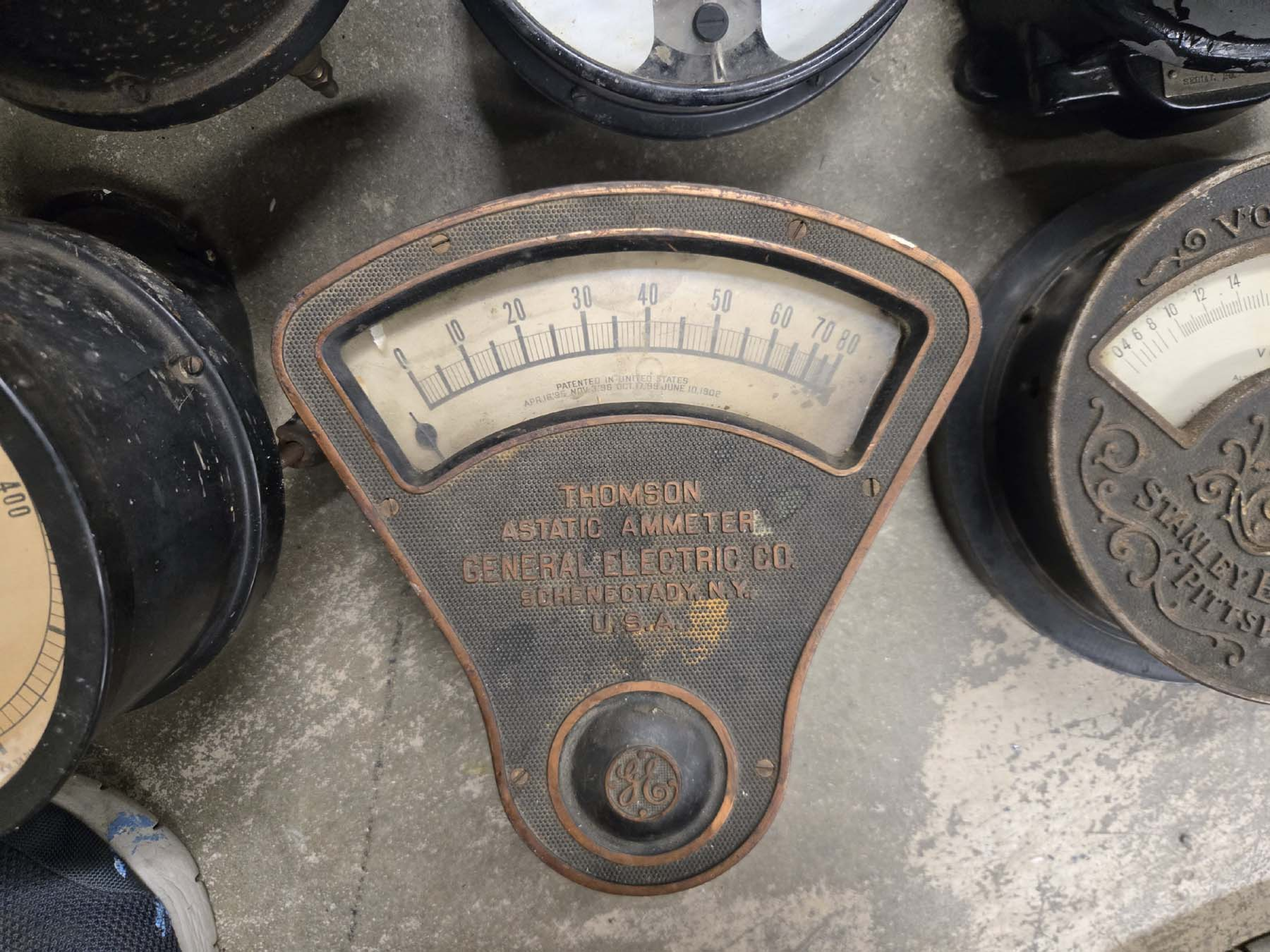
Certified 3-31-11 By J. McClurg

ROLLER-SMITH COMPANY,
BETHLEHEM, PA., U. S. A.

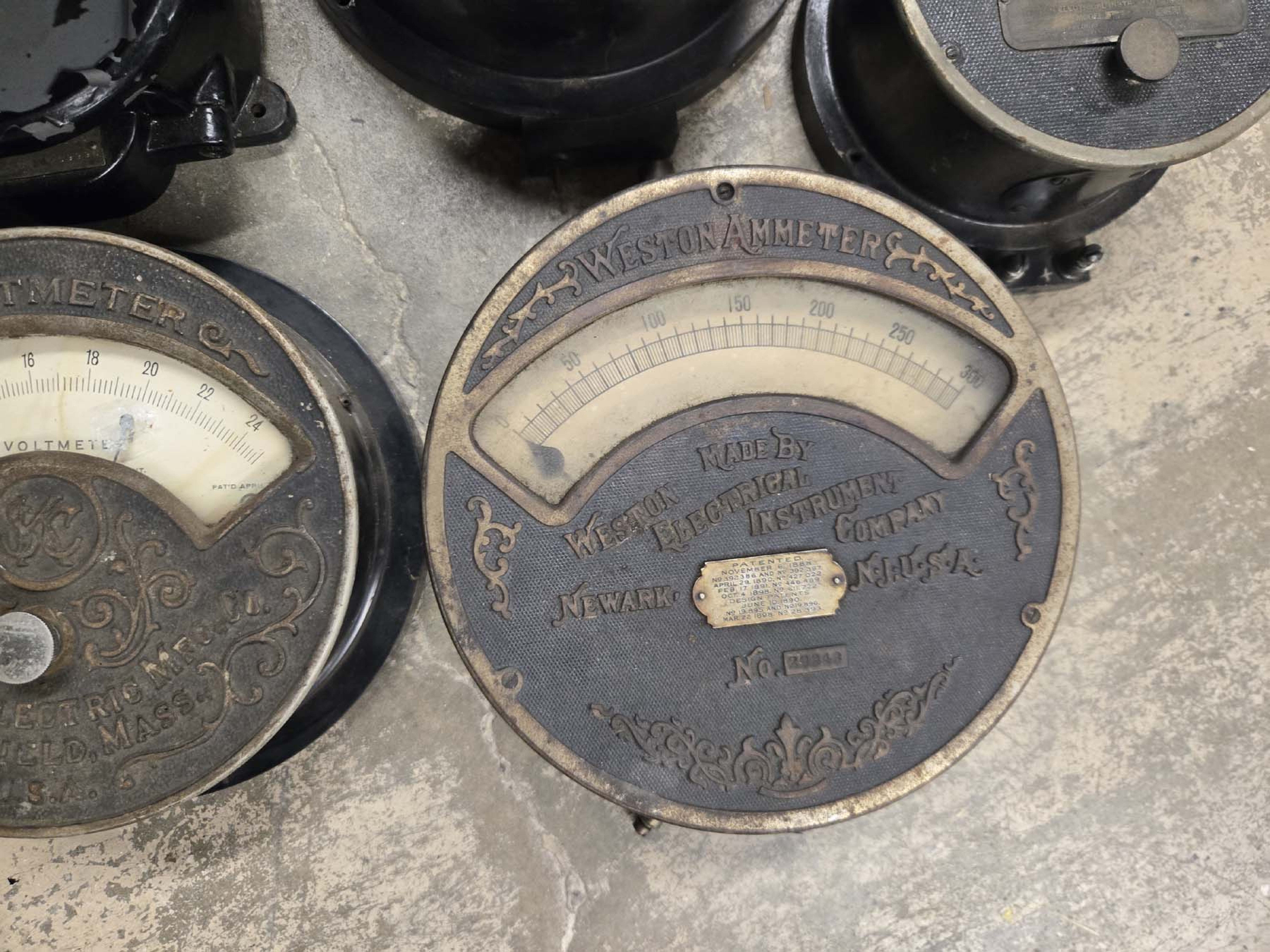
1107
2765
CYCLES
WESTINGHOUSE
200
400
600
AMPERES
WESTINGHOUSE ELEC & MFG CO
PITTSBURGH, PA. U.S.A.
A
SINGLE PHASE
THREE WIRE
WATTMETER
KILOWATTS
KILOWATTS
THOMSON
ASTATIC AMMETER
GENERAL ELECTRIC CO.
SCHENECTADY, N.Y.
U.S.A.
VOLTMETER
STANLEY ELECTRIC MFG. CO.
PITTSFIELD, MASS.

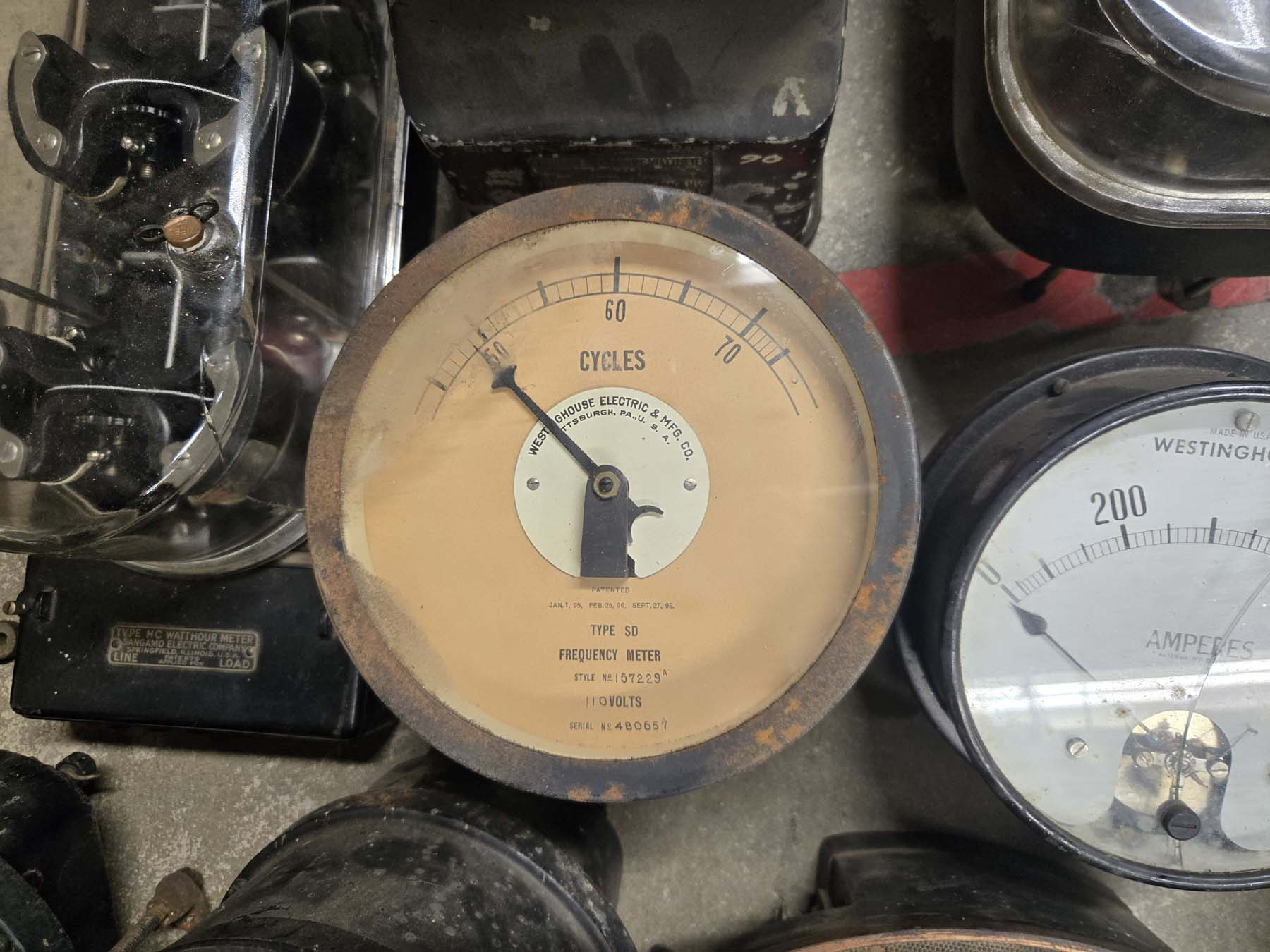

KILOWATTS
0
20
40
60
80
100
120
WESTINGHOUSE ELECTRIC & MFG. CO.
PITTSBURGH, PA., U. S. A.
PATENTED
DEC. 25, 96. JULY 11, 05
TYPE SM
A.C. WATTMETER
STYLE № S33024
60 CYCLES
SERIAL № 489591
5 AMPERES 100 VOLTS 500 WATTS IN METER CIRCUIT=120 K.W. ON DIAL
TYPE HC WATTHOUR METER
SANGAMO ELECTRIC COMPANY
SPRINGFIELD, ILLINOIS, U.S.A.
LINE
400
800

TYPE HC WATTHOUR METER
SANGAMO ELECTRIC COMPANY
SPRINGFIELD, ILLINOIS, U.S.A.
LINE PATENTS APPLIED FOR LOAD
0
KILOWATTS
400
400
800
800
WESTINGHOUSE ELECTRIC & MFG. CO.
PITTSBURGH, PA., U. S. A.
PATENTED
DEC. 25, 96. JULY 11, 05
TYPE S.M.
A.C. WATTMETER
STYLE No S.33024
60 CYCLES
SERIAL No 475035
5 AMPERES 100 VOLTS 500 WATTS IN METER CIRCUIT – 800 K.W. ON DIAL
100
120
0
10
20
30

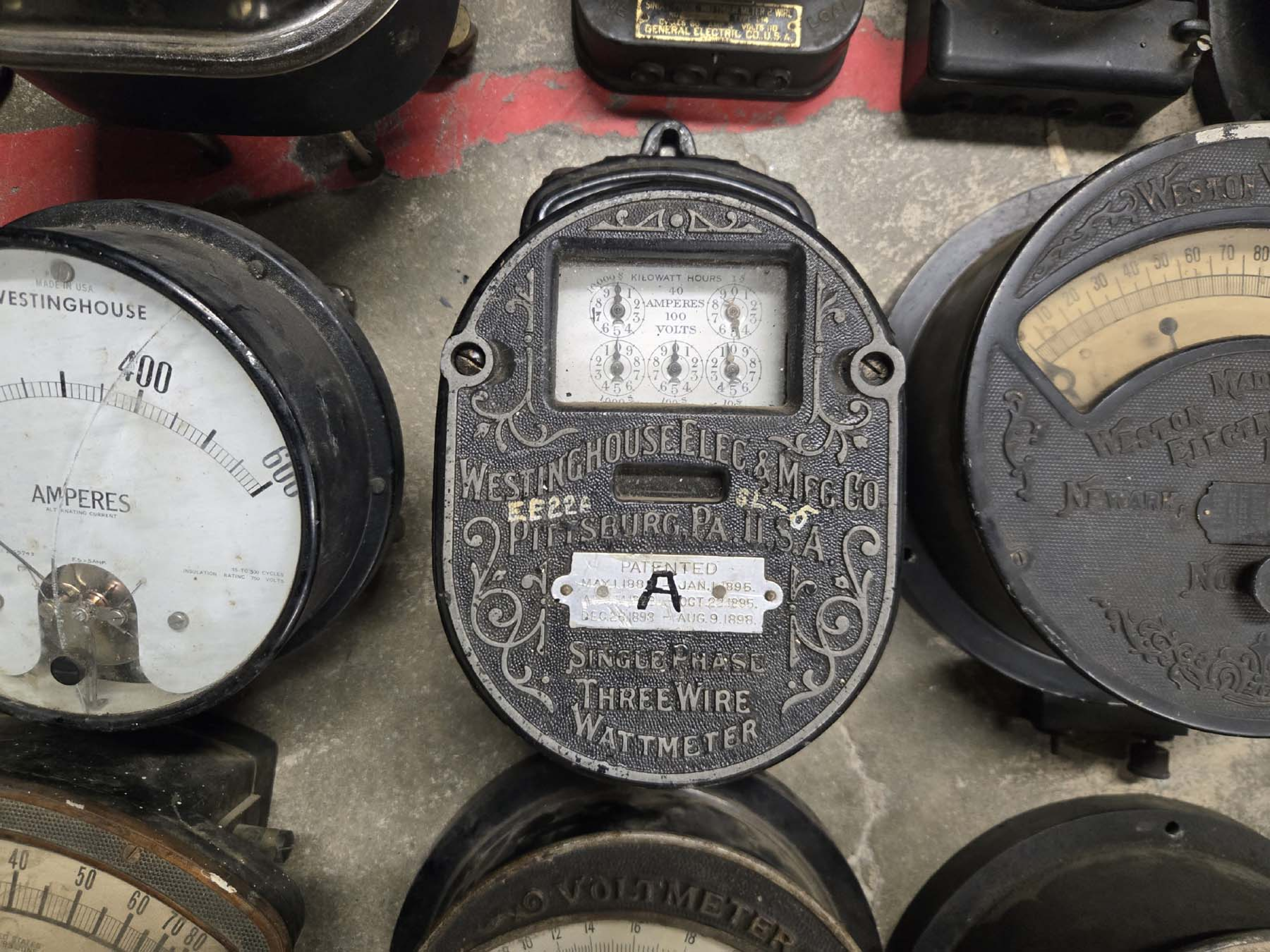

0 10 20 30 40 50 60 70 80
PATENTED IN UNITED STATES
APR.16'95 NOV.3'96 OCT.17,'99 JUNE 10,1902
THOMSON
ASTATIC AMMETER
GENERAL ELECTRIC CO.
SCHENECTADY, N.Y.
U.S.A.
GE
400
VO
04 6 8 10 12 14
STANLEY E
PITTS

VOLTMETER
0 4 6 8 10 12 14 16 18 20 22 24
VOLTMETER
PAT'D APRIL
SKC
STANLEY ELECTRIC MFG. CO.
PITTSFIELD, MASS.
U.S.A.
50 60 70 80
10, 1902

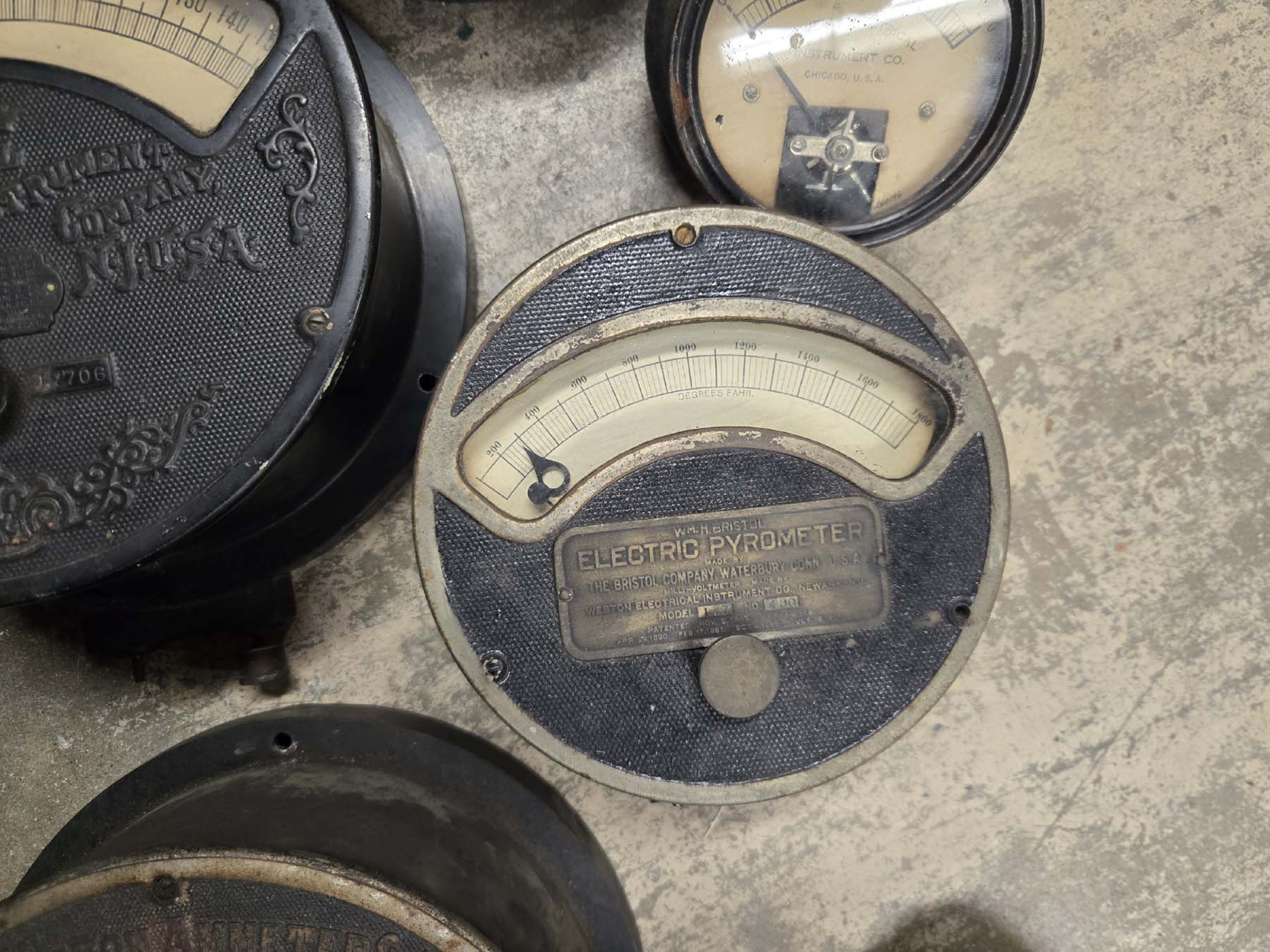

WESTON AMMETER
0
50
100
150
200
250
300
MADE BY
WESTON ELECTRICAL INSTRUMENT COMPANY
NEWARK. N.J. U.S.A.
PATENTED
NOVEMBER 6. 1888
DESIGN PATENTS
JUNE 10. 1890
NO.
TMETER
16
18
20
22
24
VOLTMETE
PAT'D APRI
ELECTRIC MFG. CO.
IELD, MASS.
U.S.A.


TYPE HC WATTHOUR METER
SANGAMO ELECTRIC COMPANY
SPRINGFIELD, ILLINOIS, U.S.A.
LINE
LOAD
60
50
70
CYCLES
WESTINGHOUSE ELECTRIC & MFG. CO.
PITTSBURGH, PA., U. S. A.
PATENTED
JAN.1, 95, FEB.25, 96, SEPT.27, 98.
TYPE SD
FREQUENCY METER
STYLE No 157229A
110 VOLTS
SERIAL No 480657
MADE IN USA
WESTINGHO
200
AMPERES

MADE IN USA
WESTINGHOUSE
0
200
400
600
AMPERES
ALTERNATING CURRENT
TYPE SY-2 STYLE 701043
C.T. = 600/5
F.S. = 5 AMP
INSULATION RATING
60
70
CYCLES
USE ELECTRIC & MFG. CO.
BURGH, PA., U. S. A.
PATENTED
TYPE SD
REQUENCY METER
STYLE No 157229A
110 VOLTS
SERIAL No 48065
0
10
20
30
40
50
60
70


GENERAL ELECTRIC CO. U.S.A.
MADE IN USA
WESTINGHOUSE
400
600
AMPERES
ALTERNATING CURRENT
KILOWATT HOURS
40 AMPERES
100 VOLTS
WESTINGHOUSE ELEC & MFG. CO.
PITTSBURG, PA. U.S.A.
EE224
PATENTED
MAY 1.189 JAN. 1.1895.
OCT 22.1895.
DEC.26.1893 AUG. 9.1898.
A
SINGLE PHASE
THREE WIRE
WATTMETER
WESTON
WESTON ELECTRICAL
NEWARK
VOLTMETER

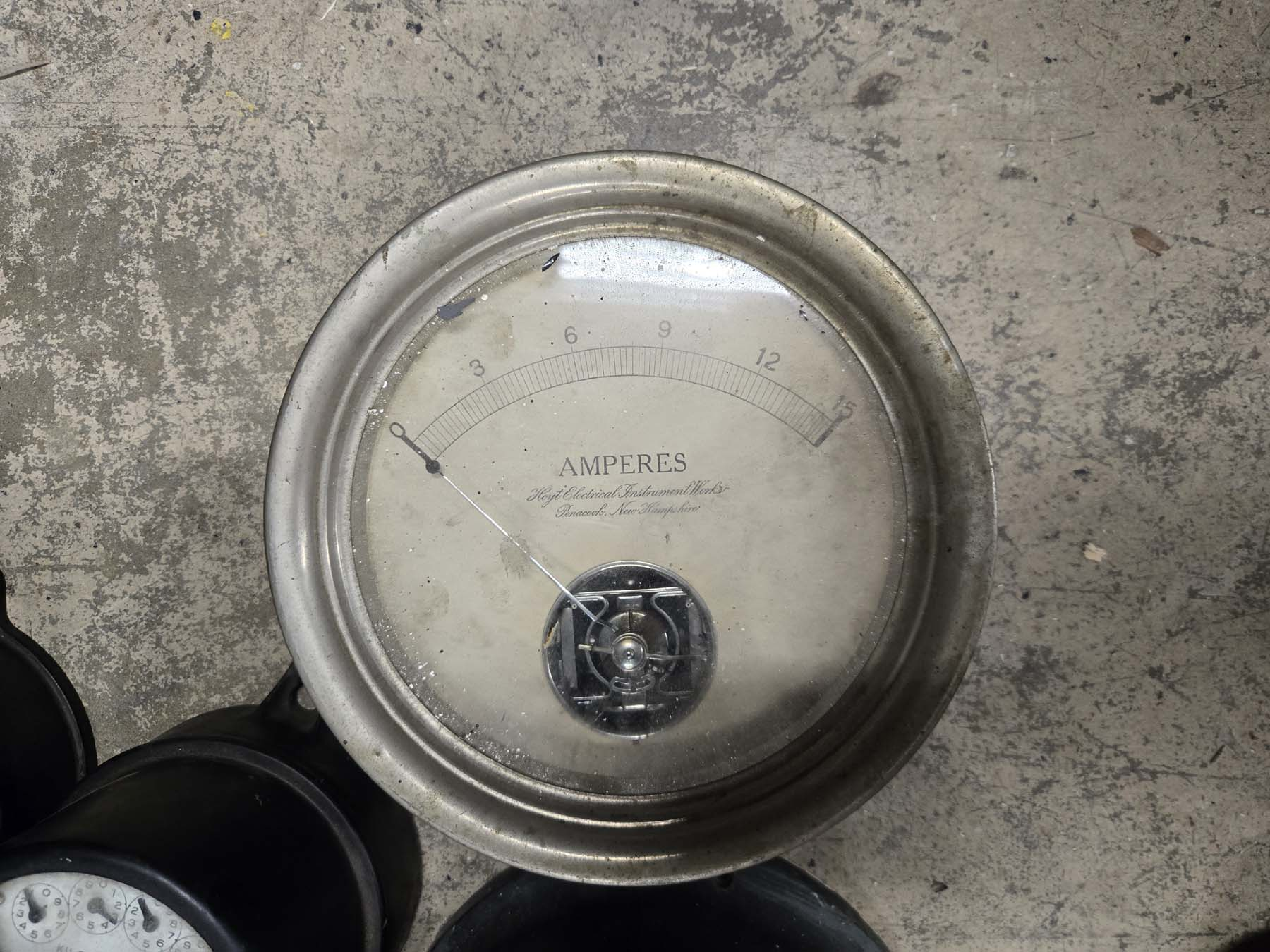
SINGLE PHASE WATTHOUR METER 2 WIRE
CYCLES 60 VOLTS 110
GENERAL ELECTRIC CO., U.S.A.
LOAD
20
WESTON VOLTMETER
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150
MADE BY
WESTON
ELECTRICAL
INSTRUMENT
COMPANY,
NEWARK,
N.J. U.S.A.
No
WATT HOURS
AMPERES
VOLTS
EC & MFG CO
ELECTRIC PY
THE BRISTOL COMPANY WATE
WESTON ELECTRICAL INSTRU
DEGREES FAHR.

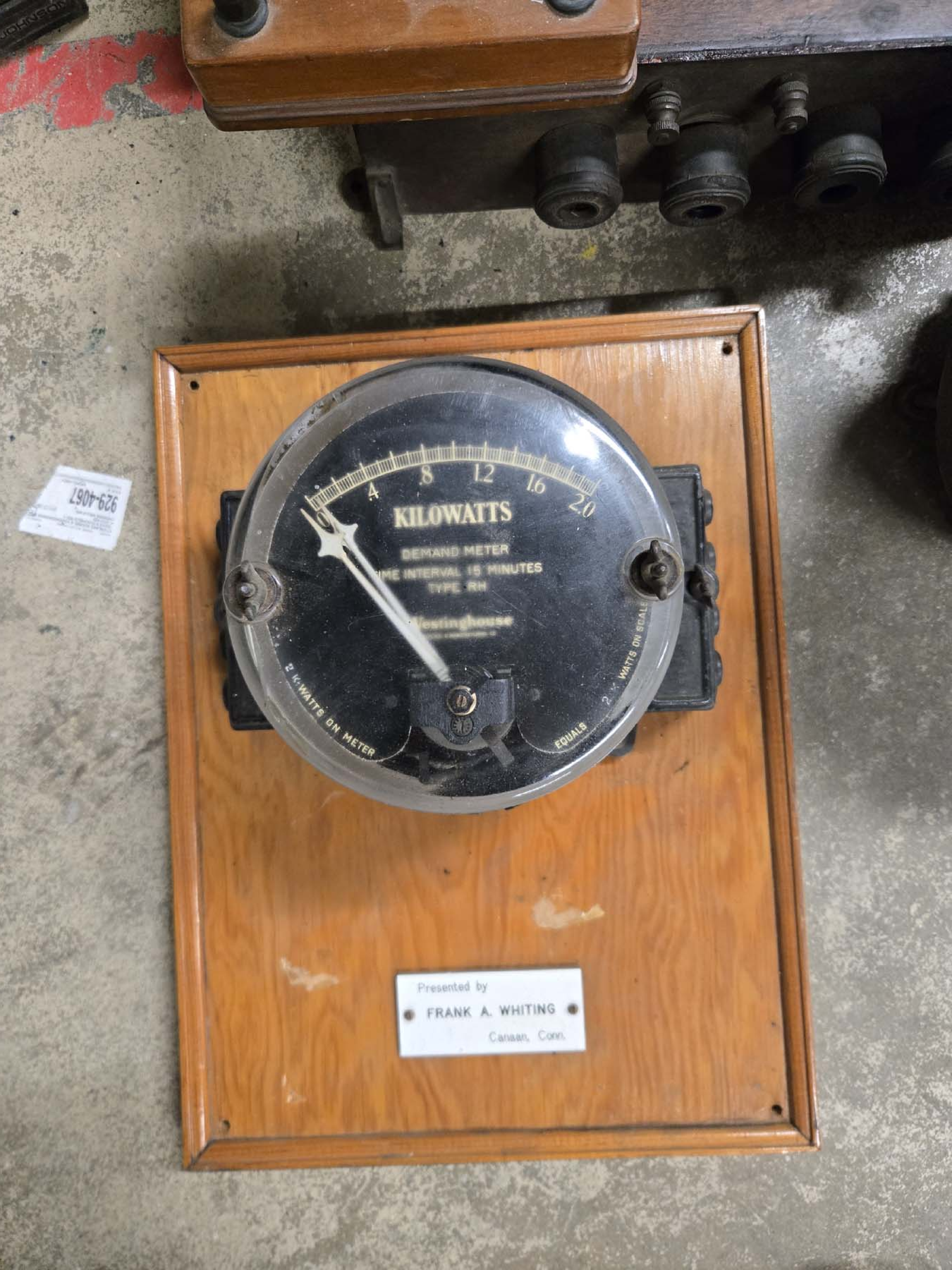

INSTRUMENT CO.
CHICAGO, U.S.A.
RUMENT
COMPANY,
N.J. U.S.A.
2706
200
400
600
800
1000
1200
1400
1600
1800
DEGREES FAHR.
WM. H. BRISTOL
ELECTRIC PYROMETER
MADE BY
THE BRISTOL COMPANY WATERBURY CONN. U.S.A.
MILLI-VOLTMETER MADE BY
WESTON ELECTRICAL INSTRUMENT CO., NEWARK, N.J.
MODEL
NO.
PATENTED NOV. 6
APR. 1890 FEB. 1891

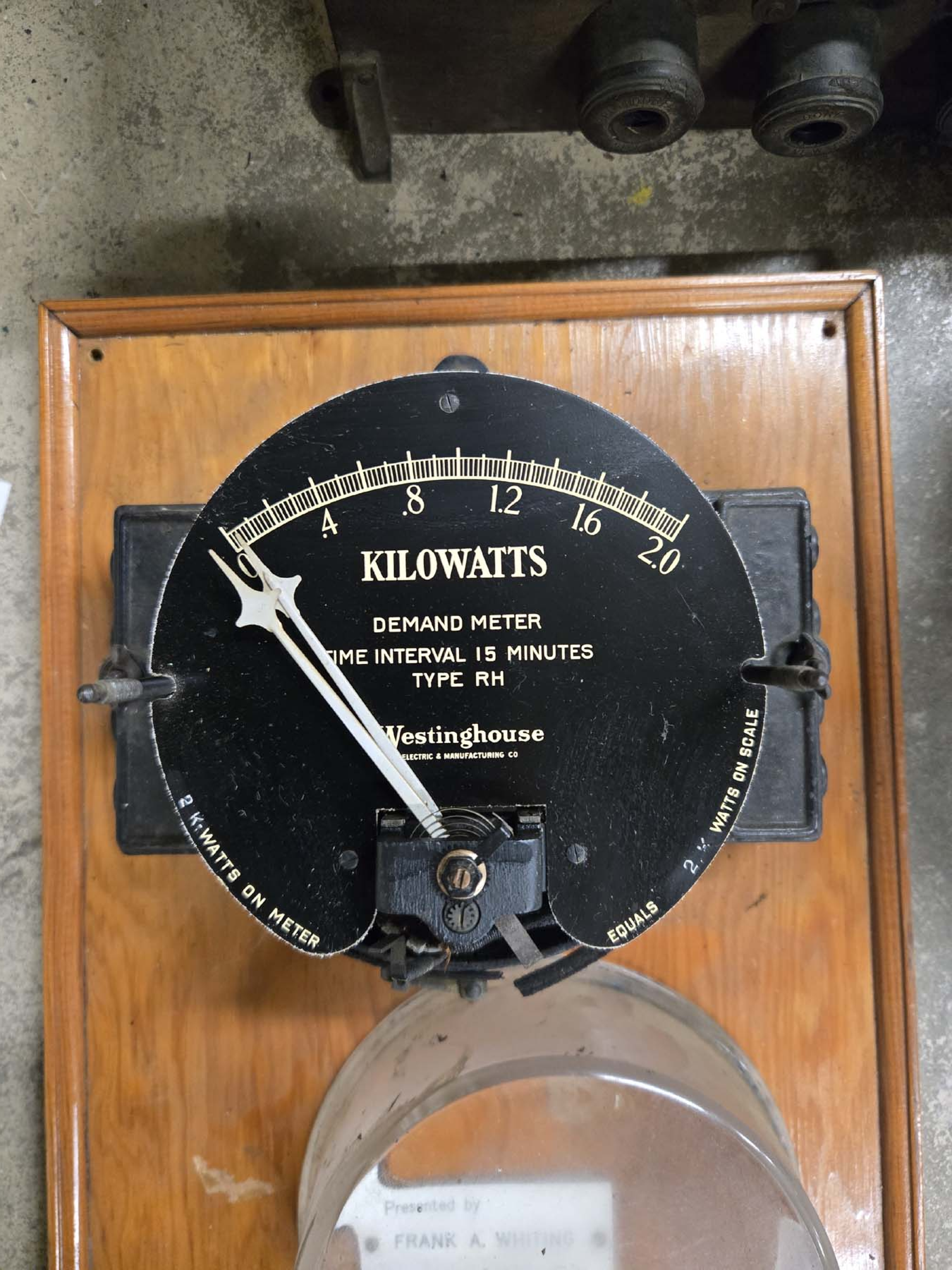
20
X
VOLTS
0
50
100
150
200
JEWELL ELECTRICAL
INSTRUMENT CO.
CHICAGO, U. S. A.
260146
130
140
200
400
600
800
1000
1200
1400
1600
1800
DEGREES FAHR.

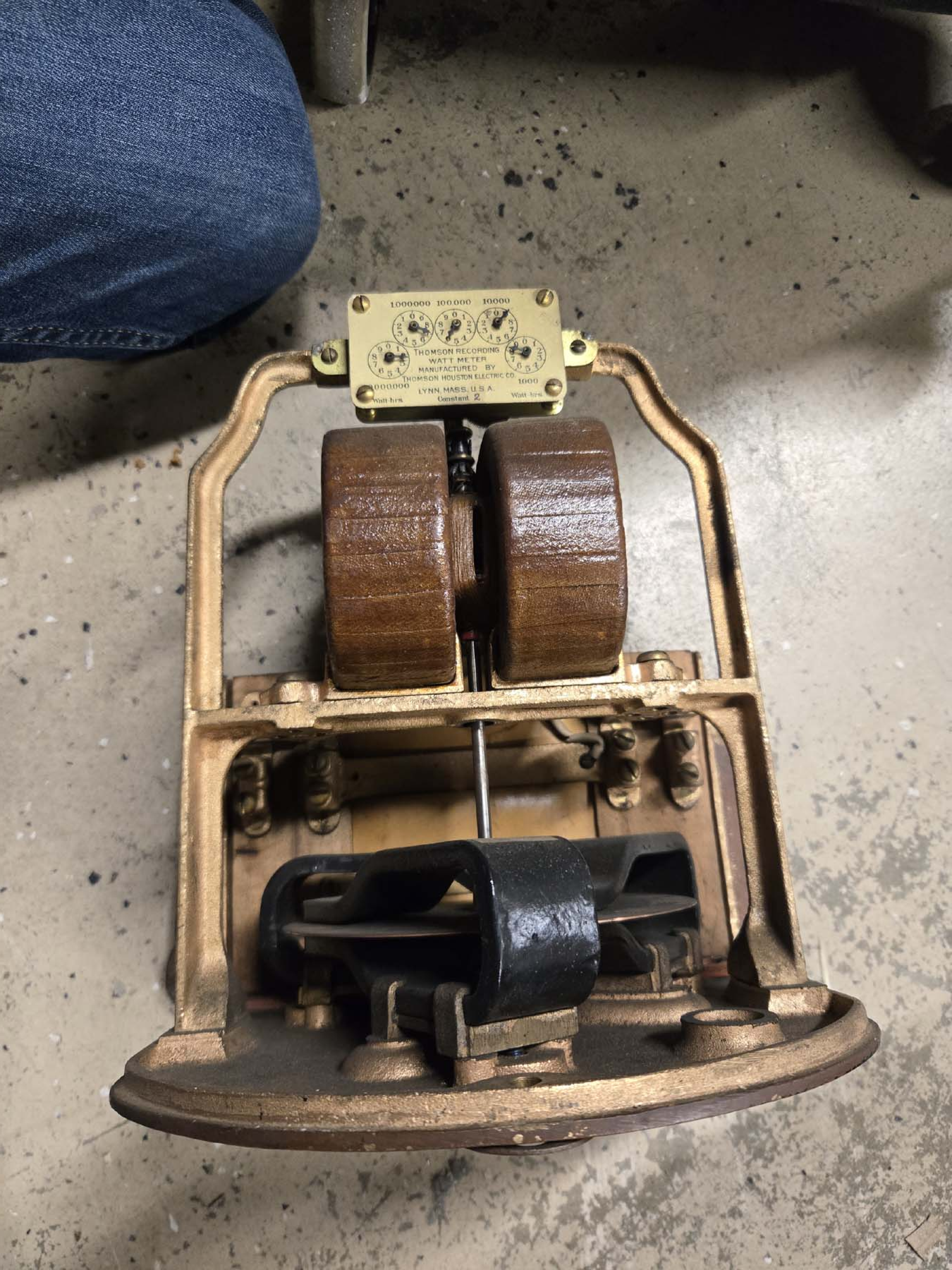
OWATT HOURS
E H
METER
65
0
1
2
3
4
5
D.C.
AMPERES
Hoyt Electrical Instrument Works
Penacook, New Hampshire
X 20

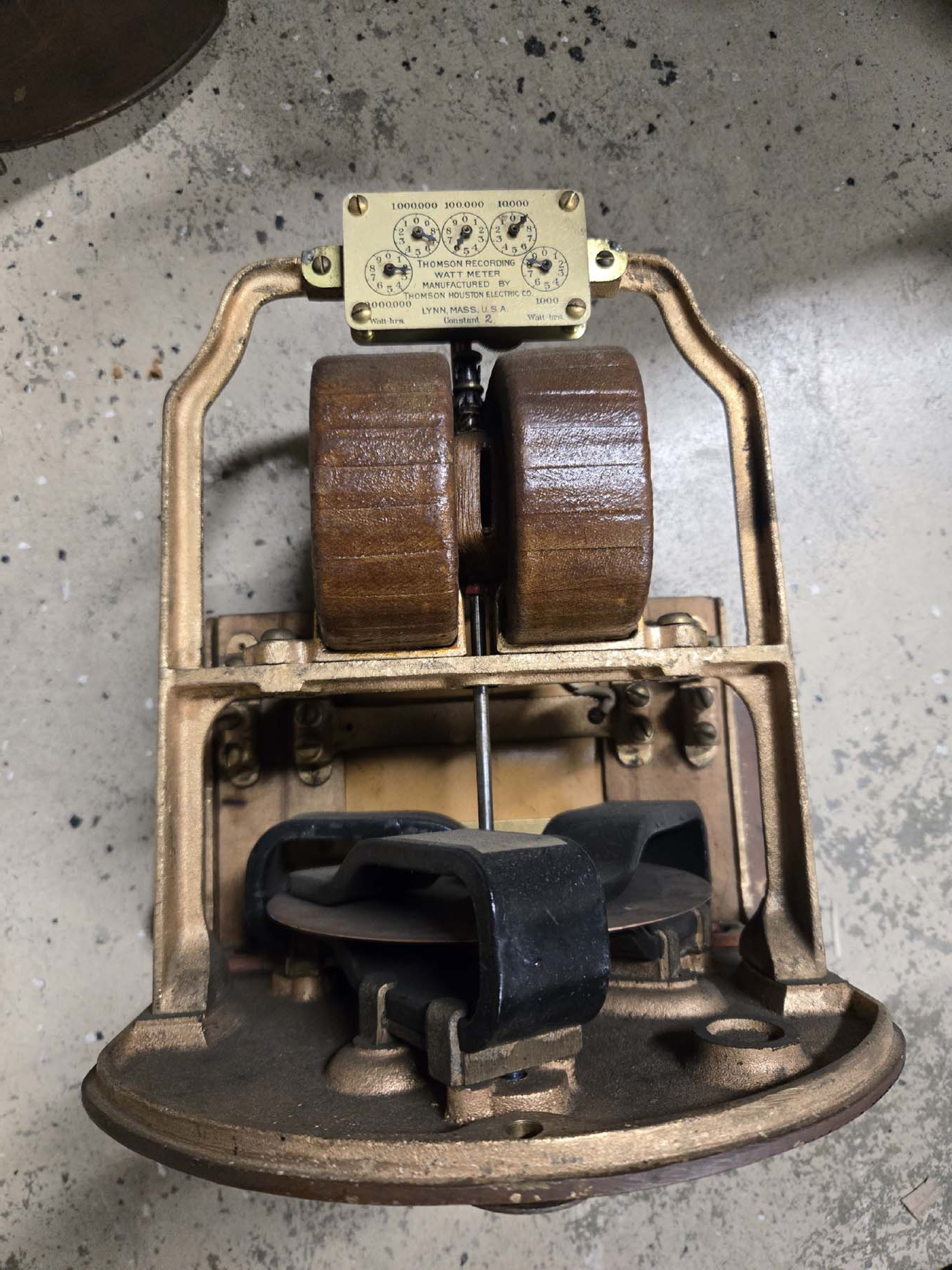
KILOWATT HOURS
1107
GENERAL ELECTRIC CO. U.S.A.
KILOWATT HOURS
TYPE H
WATTHOUR METER
2765
AMPER


3
6
9
12
15
AMPERES
Hoyt Electrical Instrument Works
Penacook, New Hampshire


0
.4
.8
1.2
1.6
2.0
KILOWATTS
DEMAND METER
TIME INTERVAL 15 MINUTES
TYPE RH
Westinghouse
2 K-WATTS ON METER
EQUALS
2 K-WATTS ON SCALE
Presented by
FRANK A. WHITING
Canaan, Conn.
929-4067


0
.4
.8
1.2
1.6
2.0
KILOWATTS
DEMAND METER
TIME INTERVAL 15 MINUTES
TYPE RH
Westinghouse
ELECTRIC & MANUFACTURING CO
2 K-WATTS ON METER
EQUALS
2 K WATTS ON SCALE
Presented by
FRANK A. WHITING


1000000
100.000
10000
THOMSON RECORDING
WATT METER
MANUFACTURED BY
THOMSON HOUSTON ELECTRIC CO.
0000000
1000
LYNN, MASS. U.S.A.
Watt-hrs.
Constant 2
Watt-hrs.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MANUFACTURED BY
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Watt-hrs.
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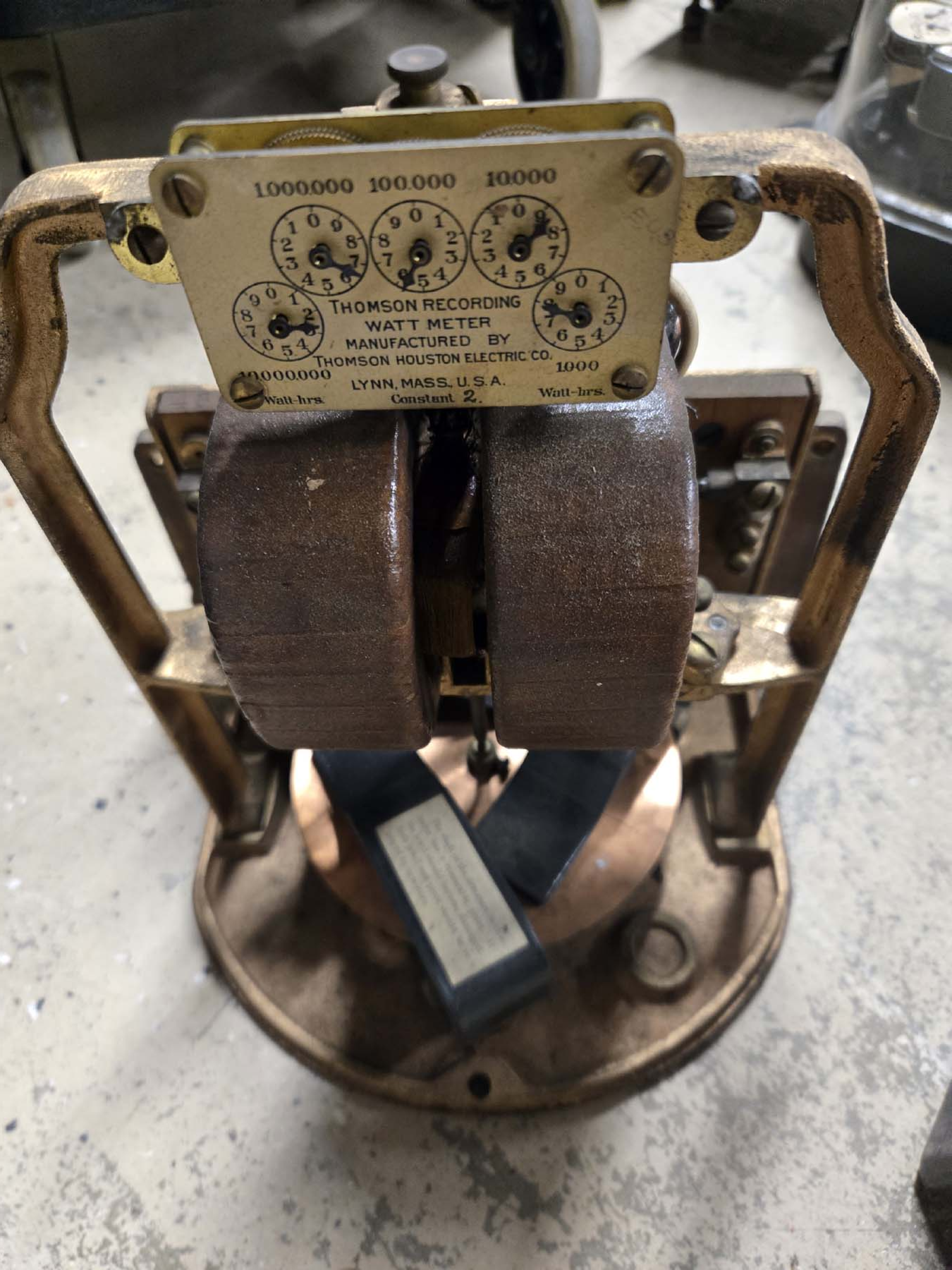
Watt-hrs.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100.000
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THOMSON RECORDING
WATT METER
MANUFACTURED BY
THOMSON HOUSTON ELECTRIC CO.
LYNN, MASS. U.S.A.
10.000.000
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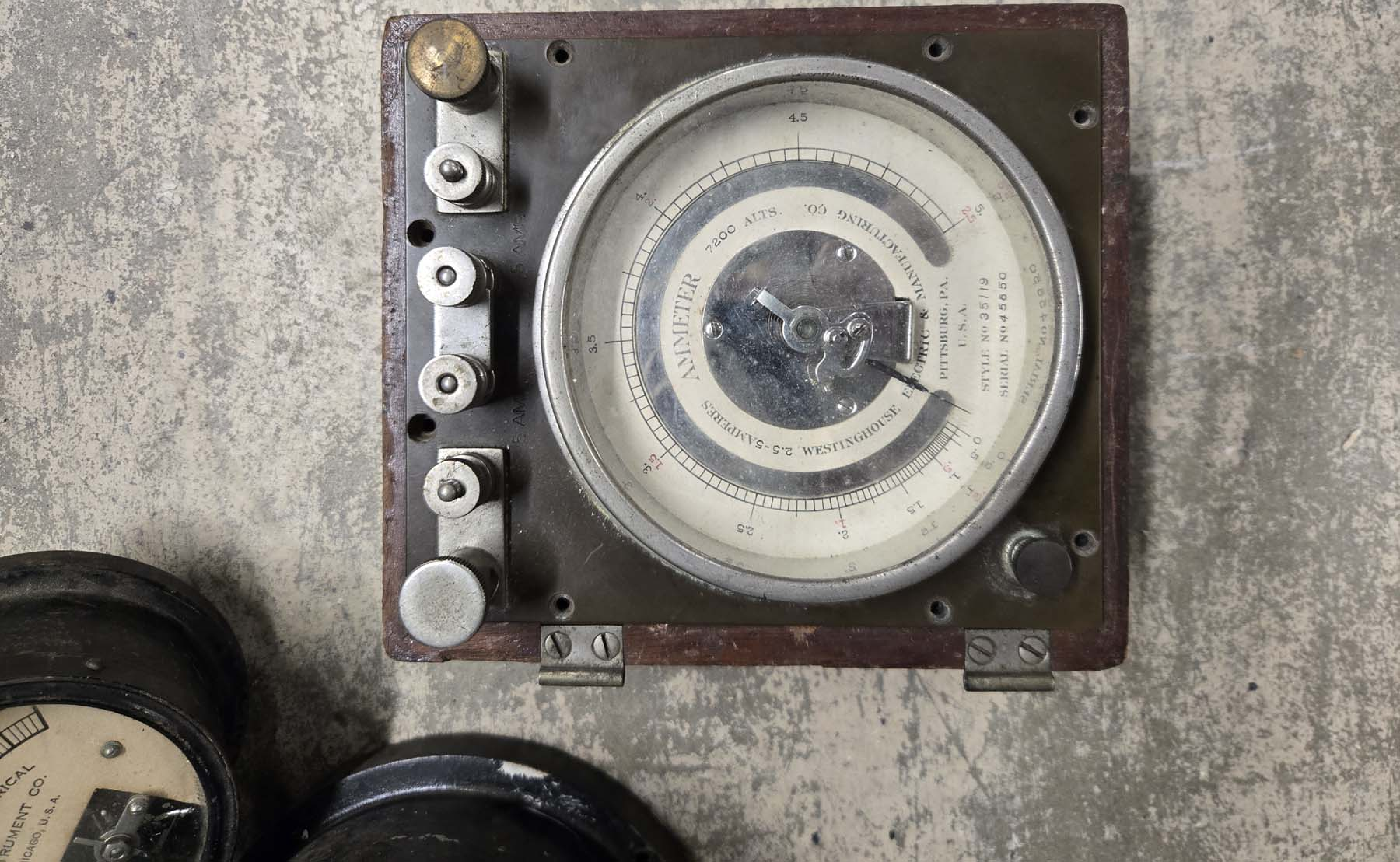
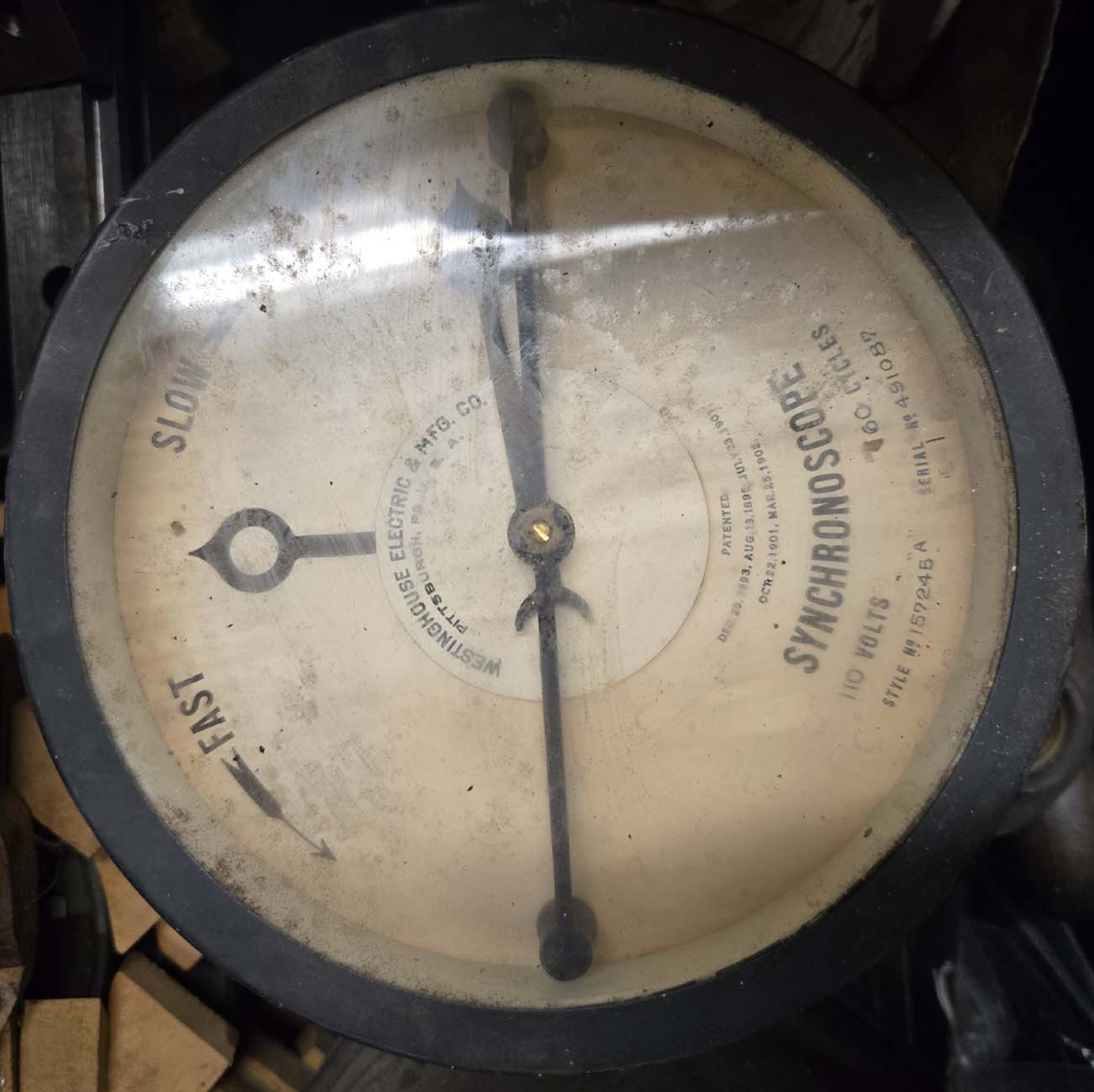
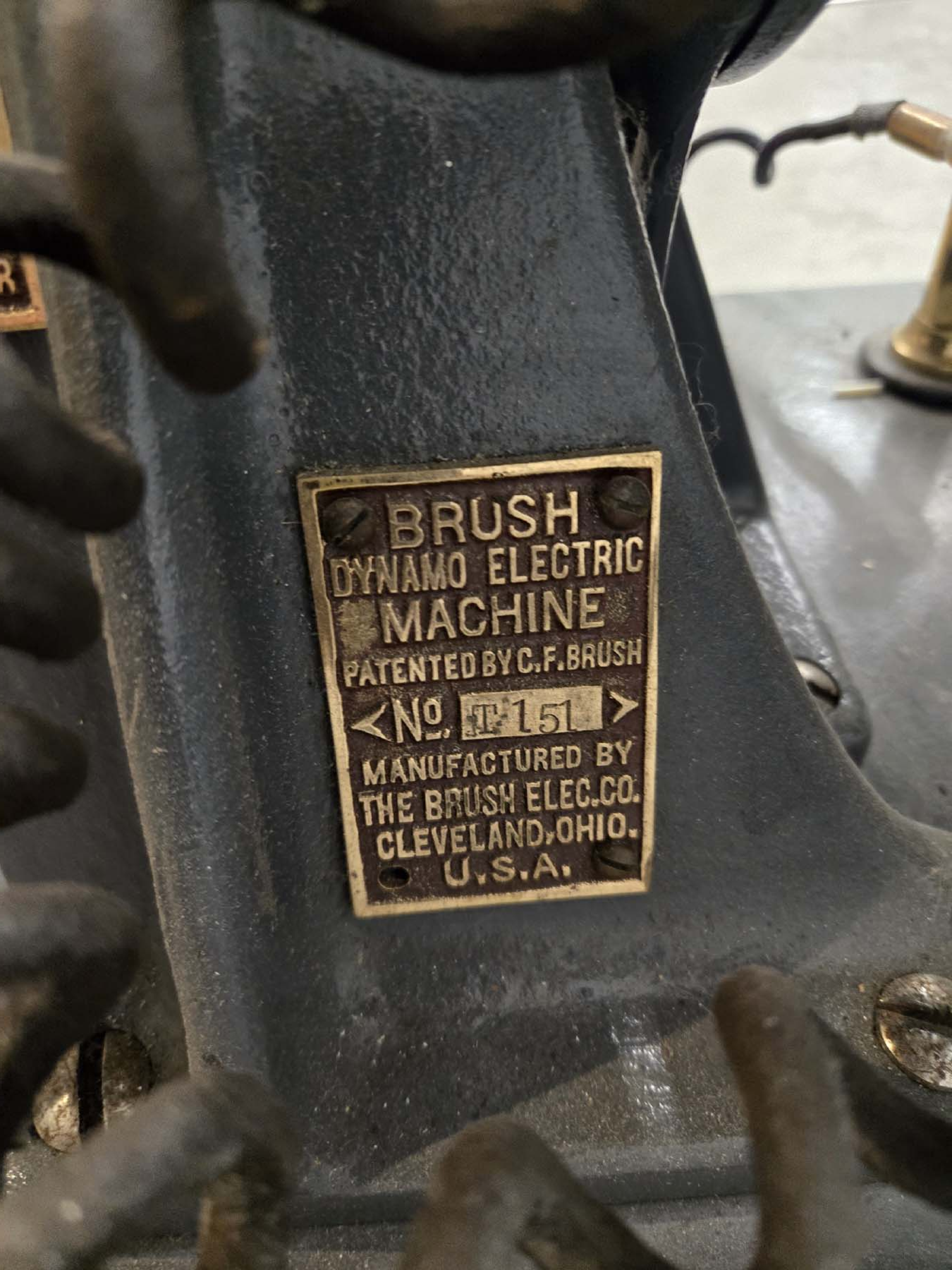
Watt-hrs.
Constant 2.
Watt-hrs.

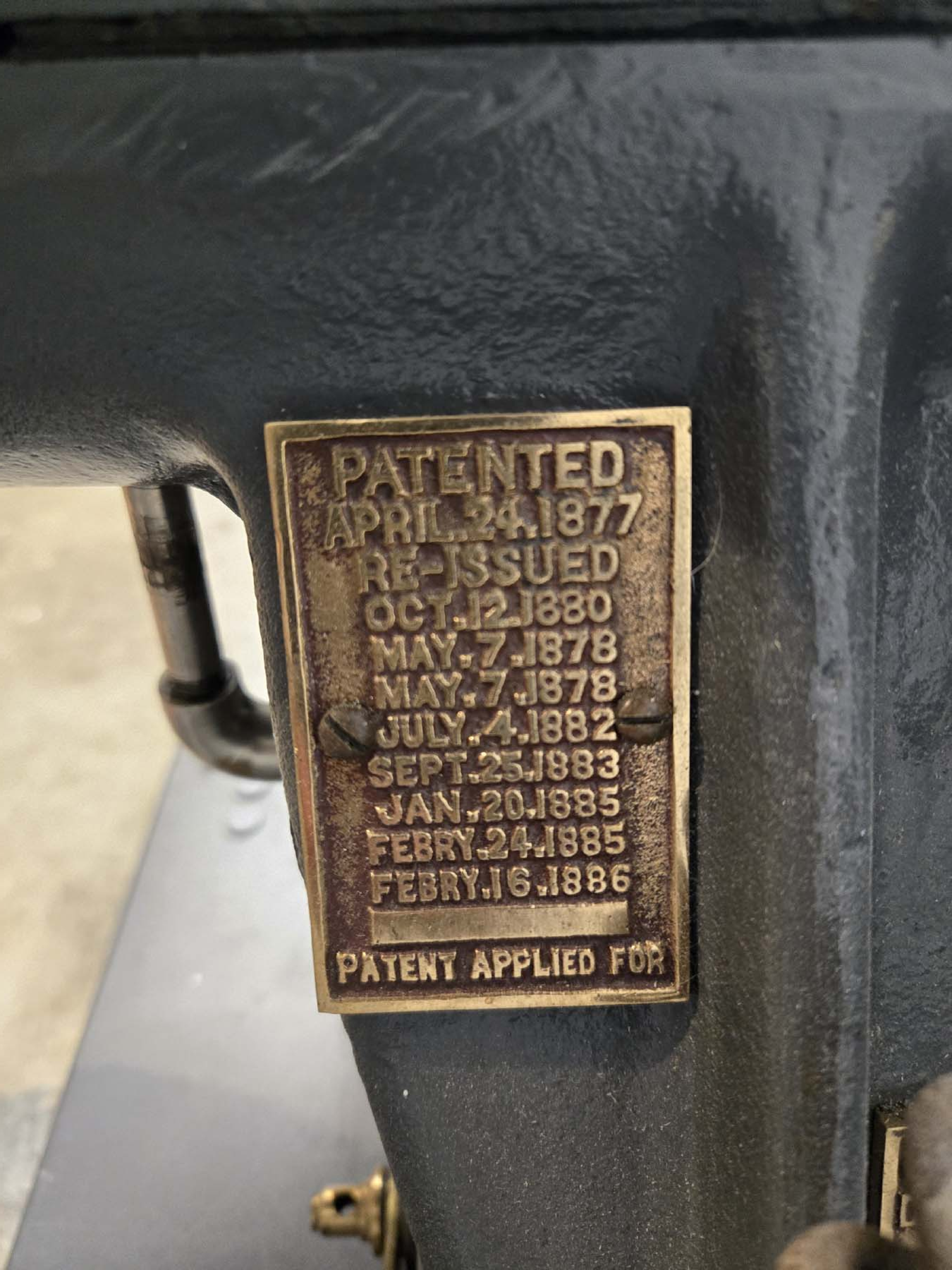

AMMETER
7200 ALTS.
2.5-5AMPERES
WESTINGHOUSE ELECTRIC & MANUFACTURING CO.
PITTSBURG, PA.
U.S.A.
STYLE No 35719
SERIAL No 45650
4.5
3.5
2.5
1.5
5 AMPS
5 AMPS
TRUMENT CO.
ICAGO, U.S.A.

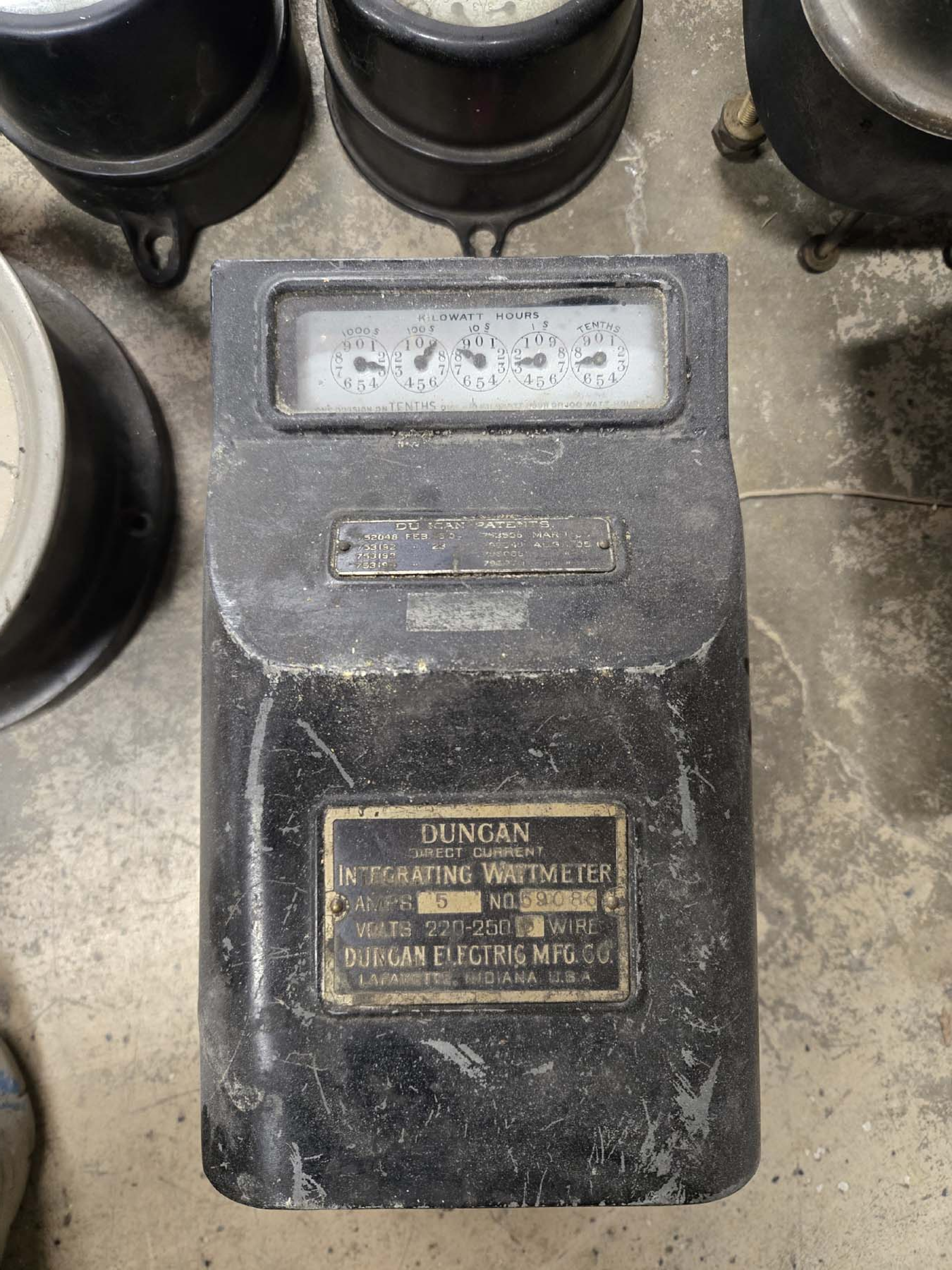
WESTINGHOUSE ELECTRIC & MFG. CO.
PITTSBURGH, PA., U. S. A.
PATENTED FEB. 25, 96. JULY 11, 05.
TYPE SM
A.C. AMMETER
45-65 CYCLES
SERIAL No 487210
AMPERES
0
300
400
500
600
700
800
900
1000
35 AMPERES IN METER CIRCUIT = 700 AMPERES ON DIAL
ELECTRIC PYROMETER
THE BRISTOL COMPANY WATERBURY CONN. U.S.A.
AMMETER
100
150
200
250

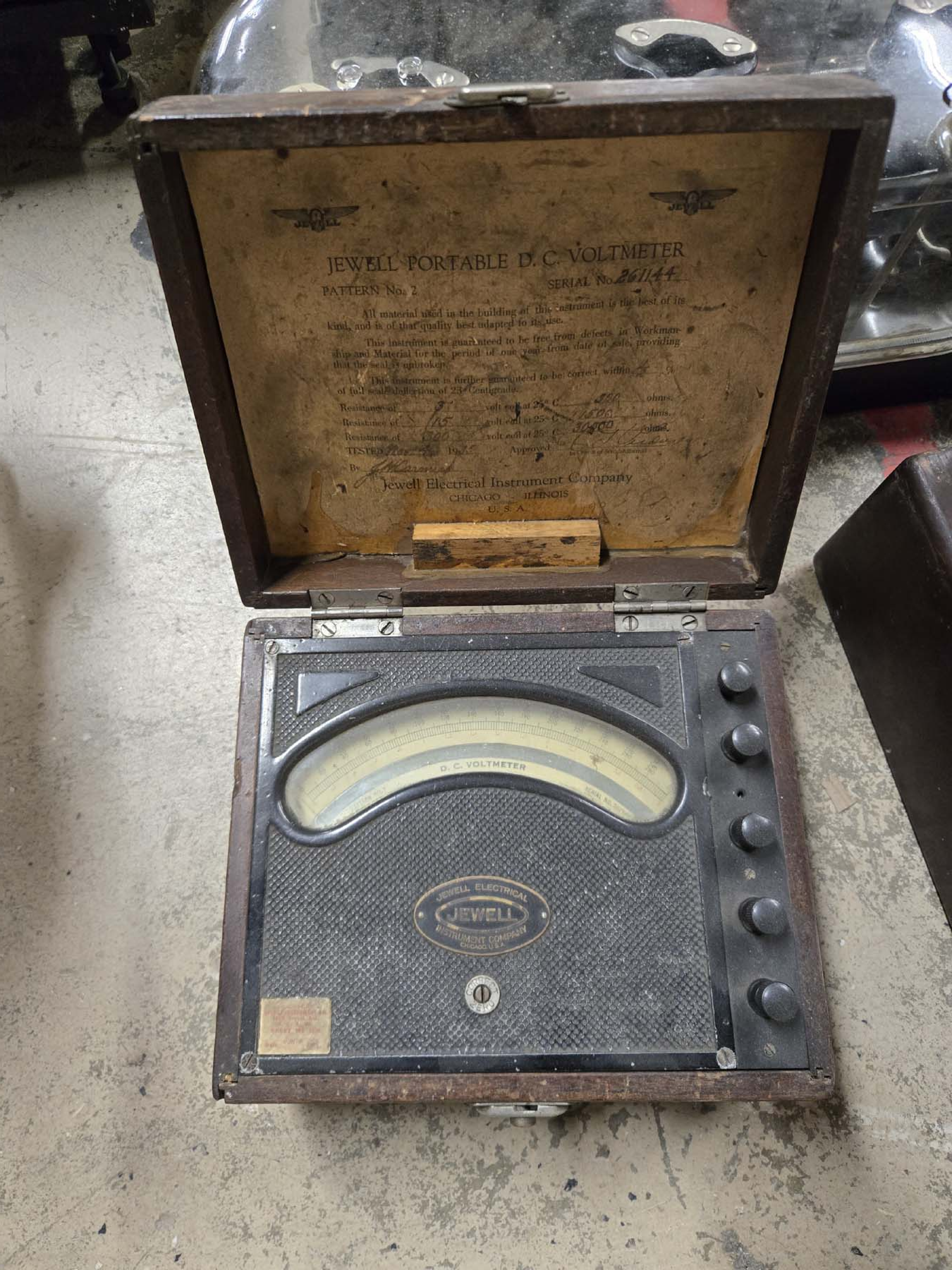
STINGHOUSE ELECTRIC & MFG. CO.
PITTSBURGH, PA., U.S.A.
VOLTS
20
40
60
80
100
120
TYPE SE
D.C. VOLTMETER
STYLE No 156203E


SLOW
FAST
WESTINGHOUSE ELECTRIC & MFG. CO.
PITTSBURGH, PA. U.S.A.
PATENTED
DEC. 26, 1893, AUG. 13, 1895, JULY 23, 1901,
OCT. 22, 1901, MAR. 28, 1905.
SYNCHRONOSCOPE
110 VOLTS
60 CYCLES
STYLE No 157245 A
SERIAL No 491082


BRUSH
DYNAMO ELECTRIC
MACHINE
PATENTED BY C.F.BRUSH
<No. T 151>
MANUFACTURED BY
THE BRUSH ELEC.CO.
CLEVELAND, OHIO.
U.S.A.


PATENTED
APRIL.24.1877
RE-ISSUED
OCT.12.1880
MAY.7.1878
MAY.7.1878
JULY.4.1882
SEPT.25.1883
JAN.20.1885
FEBRY.24.1885
FEBRY.16.1886
PATENT APPLIED FOR


KILOWATT HOURS
1000 S
100 S
10 S
1 S
TENTHS
DUNCAN PATENTS.
DUNCAN
DIRECT CURRENT
INTEGRATING WATTMETER
AMPS 5
NO. 59086
VOLTS 220-250
WIRE
DUNCAN ELECTRIC MFG. CO.
LAFAYETTE, INDIANA U.S.A.


JEWELL ELECTRICAL
JEWELL
INSTRUMENT COMPANY
CHICAGO, U.S.A.
D. C. VOLTMETER
CORRECT ZERO

JEWELL PORTABLE D. C. VOLTMETER

PATTERN No. 2 SERIAL No. 261144

All material used in the building of this instrument is the best of its kind, and is of that quality best adapted to its use.

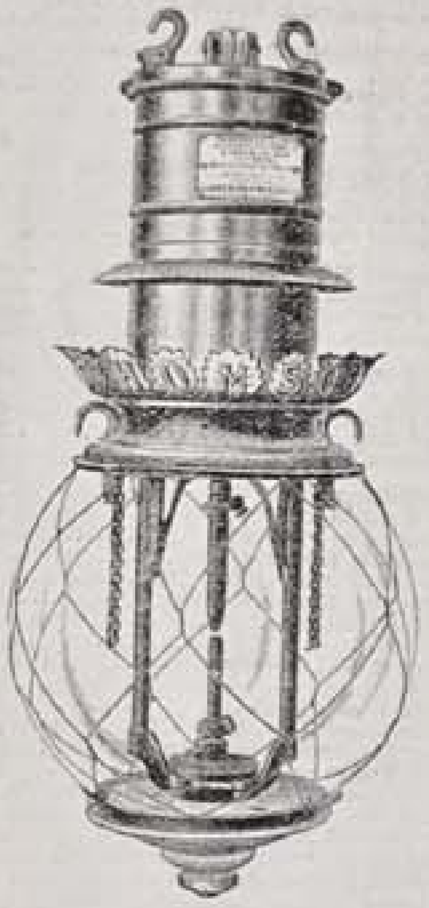
This instrument is guaranteed to be free from defects in Workmanship and Material for the period of one year from date of sale, providing that the seal is unbroken.

This instrument is further guaranteed to be correct within ¼ % of full scale deflection of 23° Centigrade.

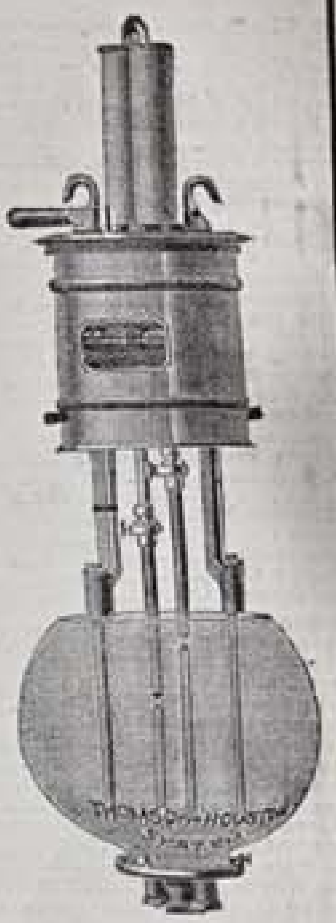
Resistance of 3 volt coil at 25° C. 390 ohms.
Resistance of 150 volt coil at 25° C. 15000 ohms.
Resistance of 300 volt coil at 25° C. 30000 ohms.
TESTED [illegible] 1925 Approved [illegible]
In Charge of Standardization
By [illegible]

Jewell Electrical Instrument Company
CHICAGO - ILLINOIS
U. S. A.

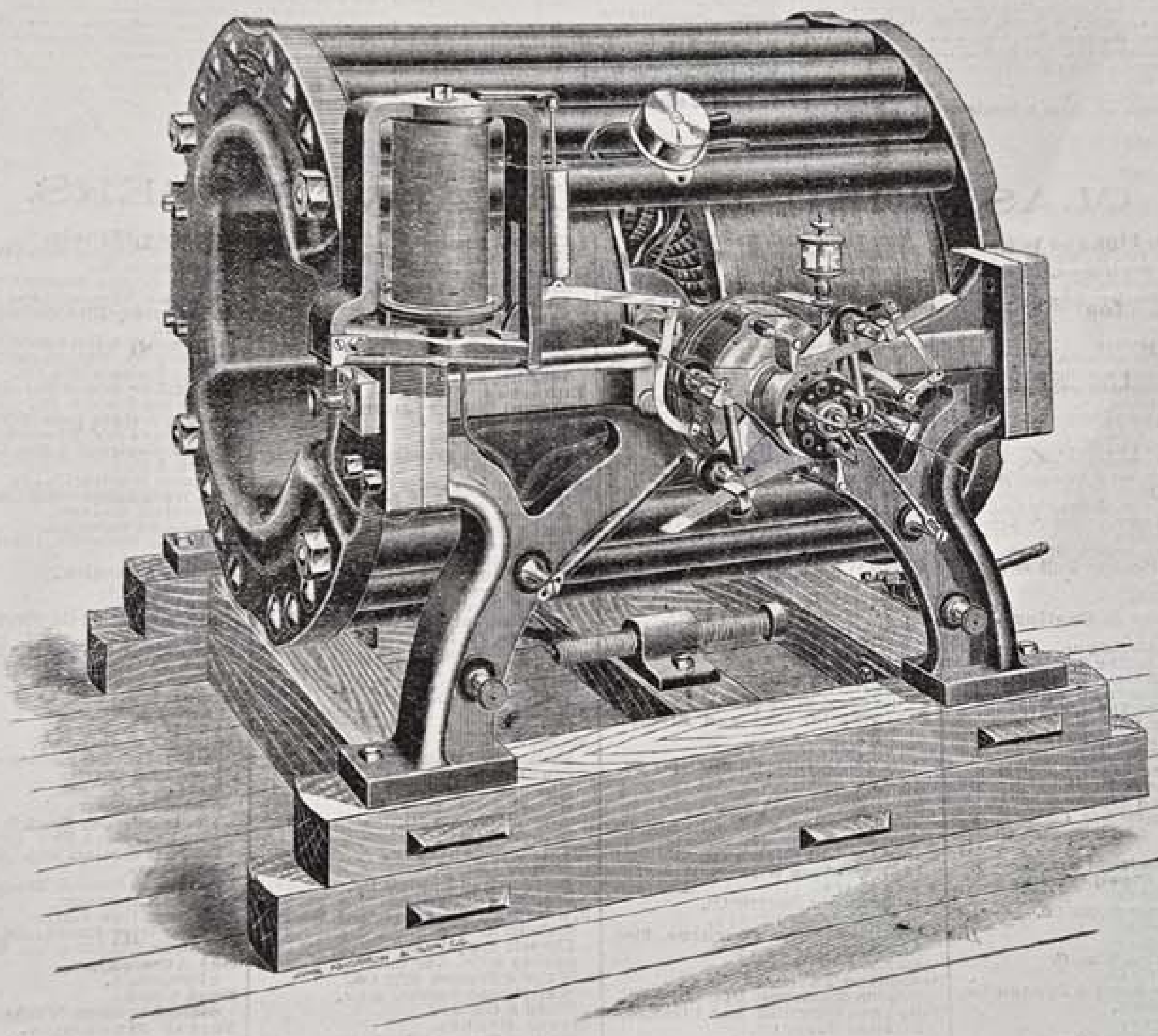
GENERAL ELECTRIC COMPANY.



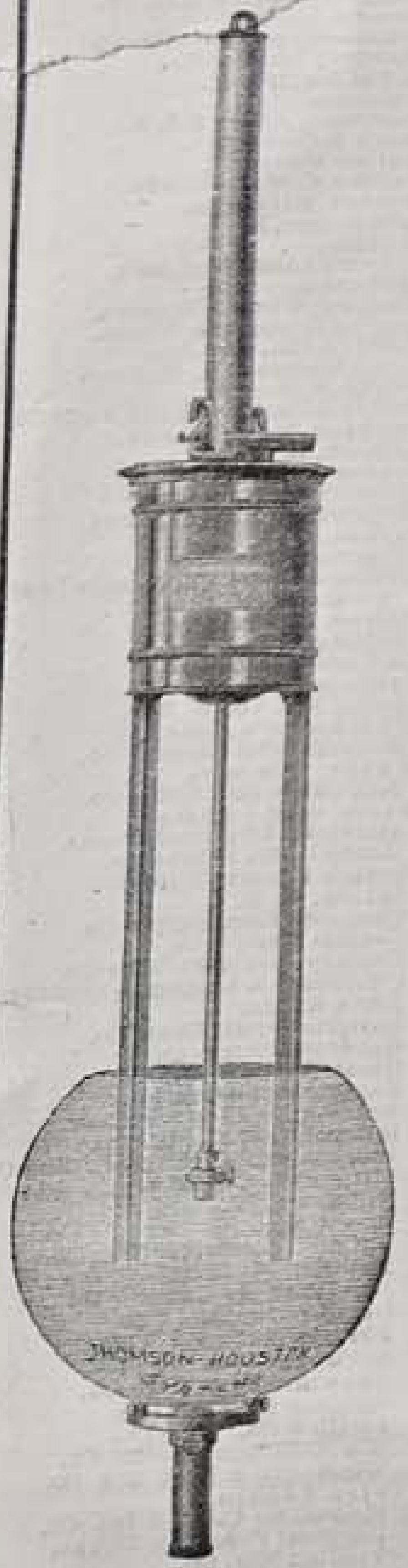
ARC LIGHTING.



A Perfect Dynamo.



A Perfect Lamp.



THE ONLY PERFECT SYSTEM

IN USE IN THE MAJORITY OF CENTRAL STATIONS IN THIS COUNTRY.

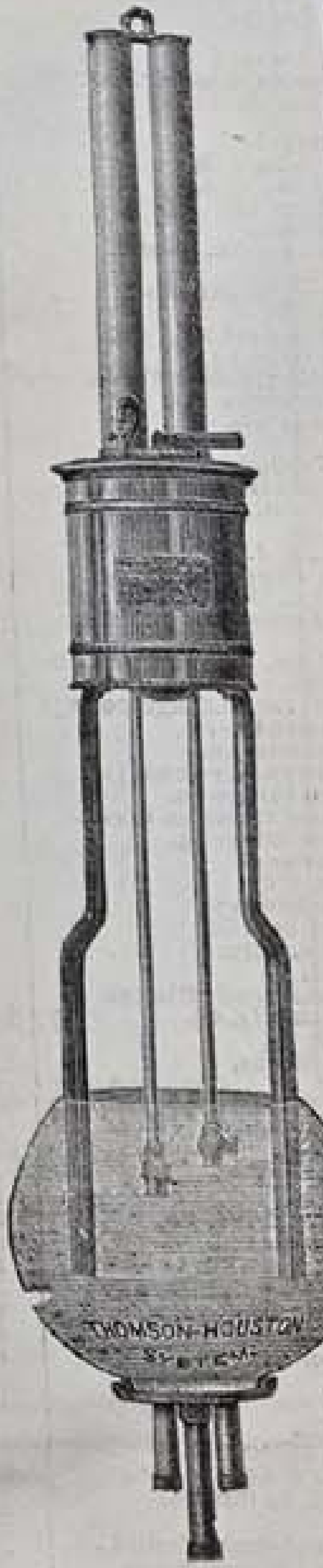
IN USE ALL OVER THE WORLD.

The Arc Lighting of the World's Fair Was Almost Exclusively Done with Our Lamps.

PRINCIPAL SALES OFFICES:

44 Broad Street, New York.
173 & 175 Adams Street, Chicago, Ill.
Fifth and Race Streets, Cincinnati, O.
Equitable Building, Atlanta, Ga.
15 First Street, San Francisco, Cal.

620 Atlantic Avenue, Boston, Mass.
509 Arch Street, Philadelphia, Pa.
401-407 Sibley Street, St. Paul, Minn.
1333 F Street N. W., Washington, D. C.
Masonic Temple, Denver, Colo.



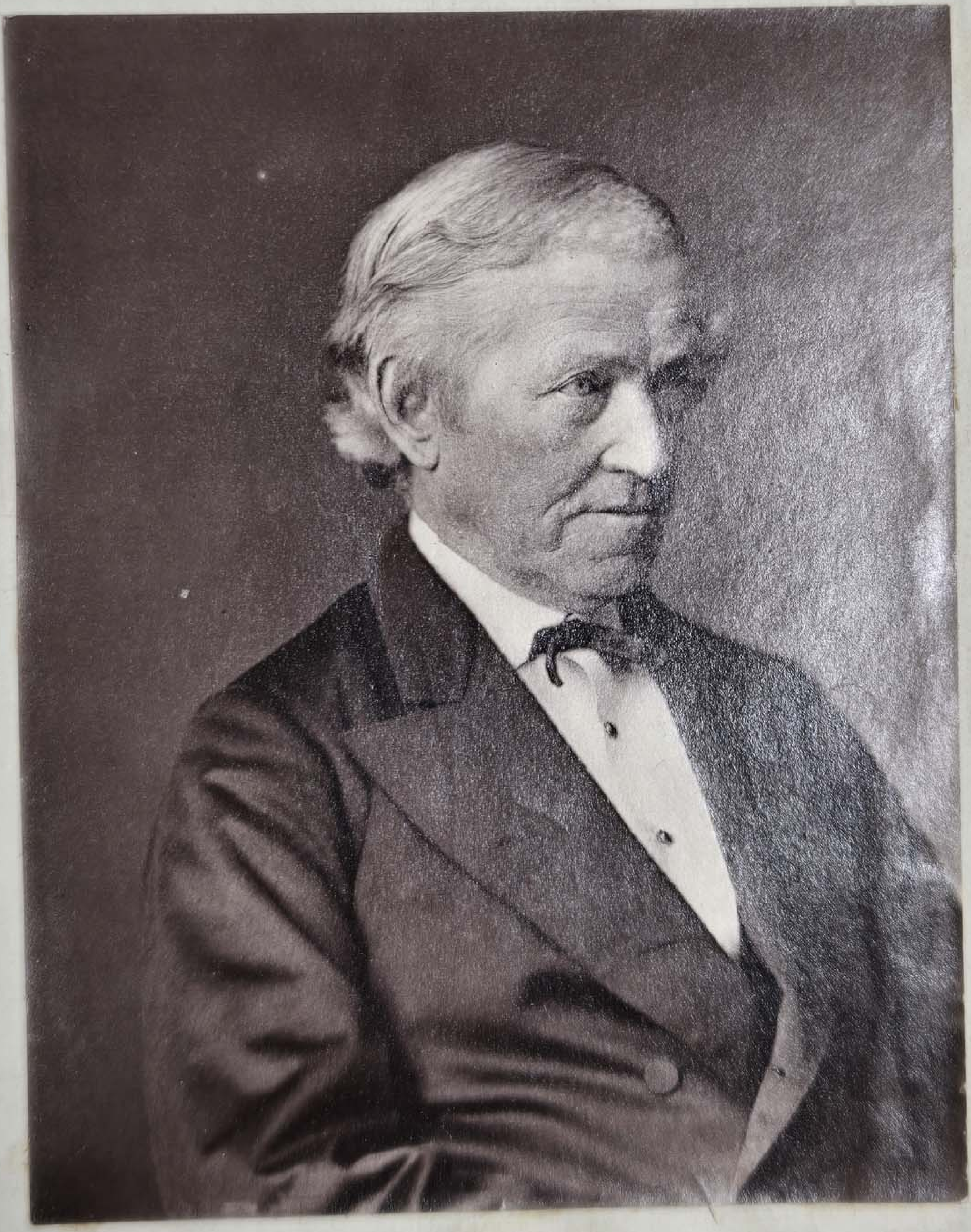
All Business Outside the United States Transacted by the THOMSON-HOUSTON INTERNATIONAL ELECTRIC CO.,
44 Broad Street, New York City.

THE
TELEGRAPHIC JOURNAL.

VOL. IV. JANUARY 1, 1876. No. 70.

THE COMPLIMENTS OF THE SEASON.

WE wish our readers a happy and prosperous New Year. We publish with the commencement of this new volume a likeness of Sir Charles Wheatstone, whose classical paper on "The Constants of a Voltaic Circuit" we are also reprinting. We propose also to publish portraits of our leadin Electricians from time to time, and we will do all we can in the future to deserve the continuance



SIR CHARLES WHEATSTONE—BORN, 1802—DIED, 1875.
(From a Photograph by MR. J. E. MAYALL, *being the last taken of* SIR CHARLES).

GEO. H. LEWARS, Secretary.
J. E. COGGESHALL, Auditor.

SAWYER-MAN ELECTRIC COMPANY,

510-534 West 23d St., New York.

Largest Incandescent Lamp Manufactory in the World.

Lamps of any Voltage.
Lamps of any Candle-Power.
Lamps to Fit any Socket.

SEND FOR CATALOGUE.

MANUFACTURERS OF AND DEALERS IN

ELECTRICAL SUPPLIES

FOR INTERIOR FITTINGS.

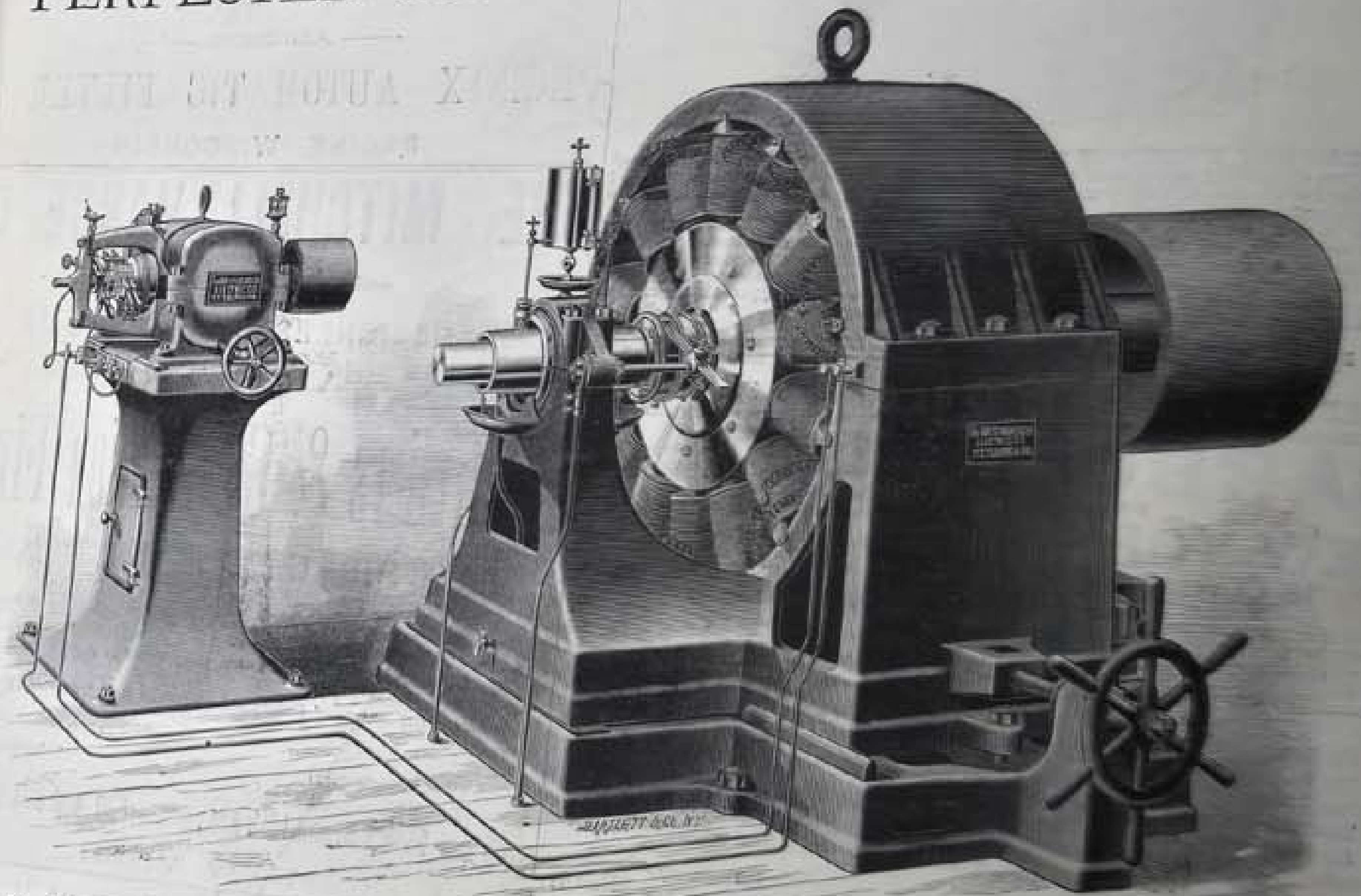
ELECTRIC AND COMBINATION FIXTURES

SERIES LAMPS AND SOCKETS.

CORRESPONDENCE SOLICITED.

THE WESTINGHOUSE ELECTRIC CO.'S SYSTEM FOR INCANDESCENT LIGHTING BY ALTERNATE CURRENTS.

PERFECTED BY YEARS OF EXPERIENCE.



DYNAMOS FOR 500, 750, 1,500, 3,000, 5,000 SIXTEEN CANDLE-POWER LAMPS.

COMPLETE CENTRAL STATION APPARATUS.

CONVERTERS. METERS.

THE WESTINGHOUSE ELECTRIC CO.,

PITTSBURGH, PENNA., U. S. A.

BOSTON, NEW YORK, CHICAGO, ST. LOUIS, CINCINNATI, SAN FRANCIS
PORTLAND, CHARLOTTE, DALLAS.

THE BEGINNING OF THE END.

Edison Company Sustained. Westinghouse Company Defeated.

SAWYER-MAN PATENT DECIDED BY THE COURT TO BE A FRAUD AND ABSOLUTELY VALUELESS.

Extracts from the Decision of Justice Bradley, Oct. 5, 1889.

Circuit Court of the United States for the Western District of Pennsylvania.

THE CONSOLIDATED ELECTRIC LIGHT COMPANY
(WESTINGHOUSE COMPANY)
versus
McKEESPORT LIGHT COMPANY
(EDISON COMPANY).

No. 5, May Term 1888.
On Bill and Final Hearing.

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"By an adroit amendment made in 1885, they say: 'Our improvement relates more especially to the incandescing conductor, **its substance,** its form and its combination with the other elements composing the lamp.' The purpose of this amendment is obvious, and needs no comment."..........................

"The fact is that Sawyer & Man were unconscious that the arc was not new, and supposed that they could get a patent for it; but, as their eyes were opened, they changed about and amended their application, and made the material of the conductor the great object—carbon made from fibrous or textile material. Compare the original with the amended application, as first stated in this opinion, and this purpose most obviously appears."..........................

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"THE BILL MUST BE DISMISSED."

PRICE OF LAMPS MUCH REDUCED.

SEND FOR OUR NEW PRICE-LIST OF LAMPS.

UNITED EDISON MANUFACTURING COMPANY, 65 Fifth Avenue, New York.

NOVEMBER 9, 1889.

CH & CO.
ST., BOSTON.

and Builders
PLANTS FOR
POWER STATIONS

Filter Co,

OIL FILTER.

the market. Simple in construction. Any filter failing satisfaction. Electric Light for itself in oil saved in from

FILTER CO
CONSIN.

VANCE CO.

AKERS OF

tion Fixtures

LECTRIC LIGHTING.

to the light medium;
have been originated which
Parlors illuminated by Electric

out with fidelity to the given

Salesroom:

838 Broadway,

HANICAL GONGS.

THE BEGINNING OF THE END.

Edison Company Sustained. Westinghouse Company Defeated.

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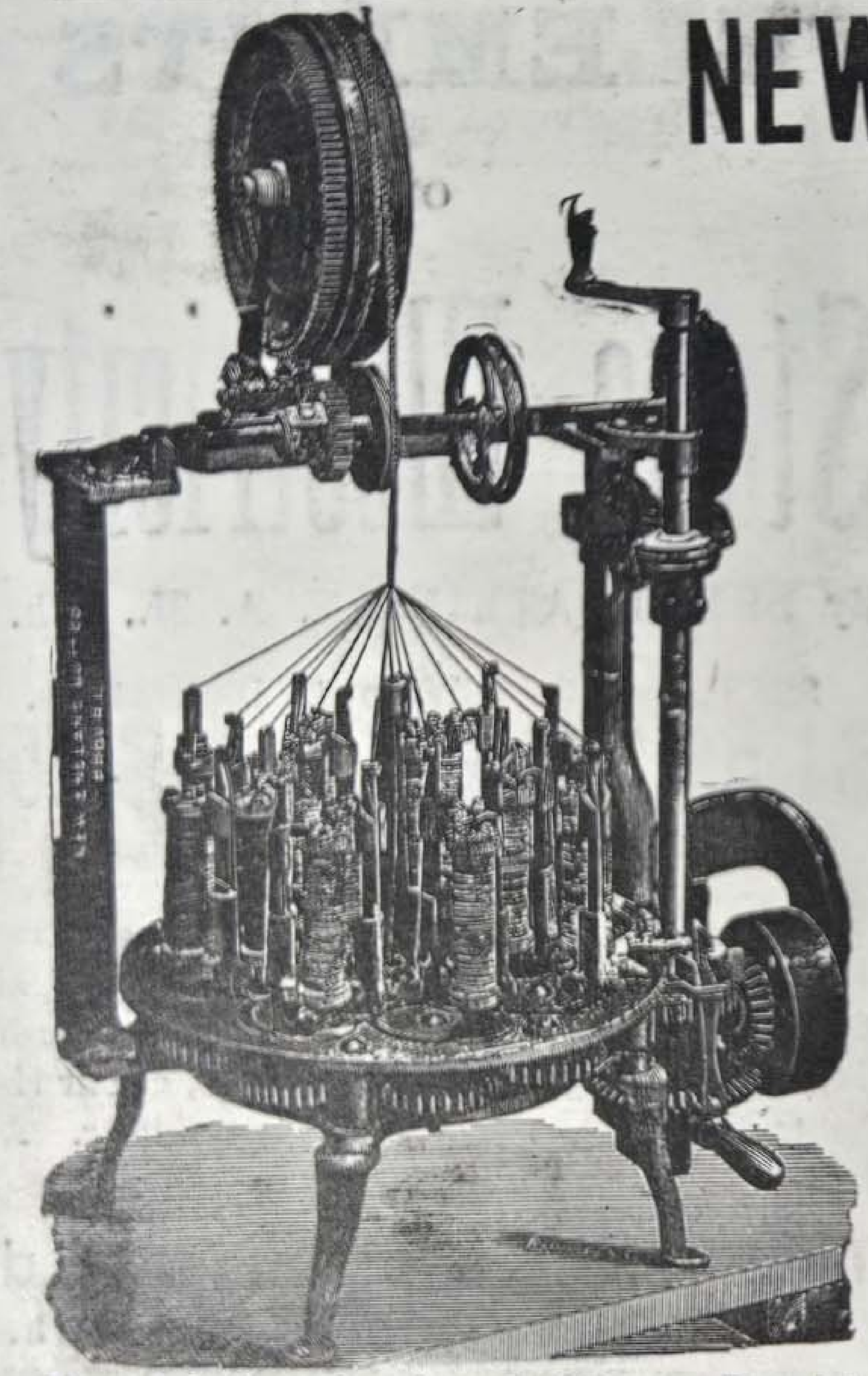
STREET CARS FOR ELECTRIC MOTORS.



No. 16 Carrier Large Gear Braider.

NEW ENGLAND BUTT CO.,

PROVIDENCE, R. I.

MANUFACTURERS OF

BRAIDING MACHINERY

FOR COVERING

Telegraph, Telephone,

AND

Electric Light Wire

ALSO

Single and Double Winders

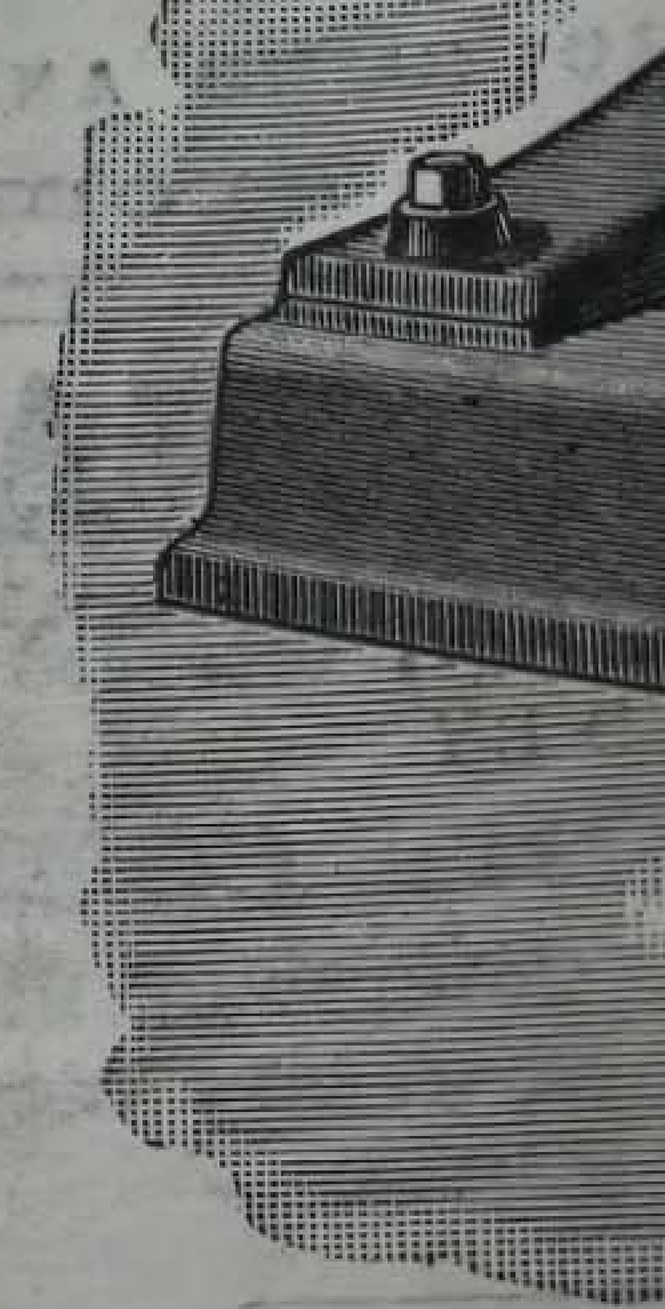
AND

BRAIDERS

OF EVERY DESCRIPTION

For Silk, Worsted and Cotton Braid.

FINE CASTINGS A SPECIALTY.

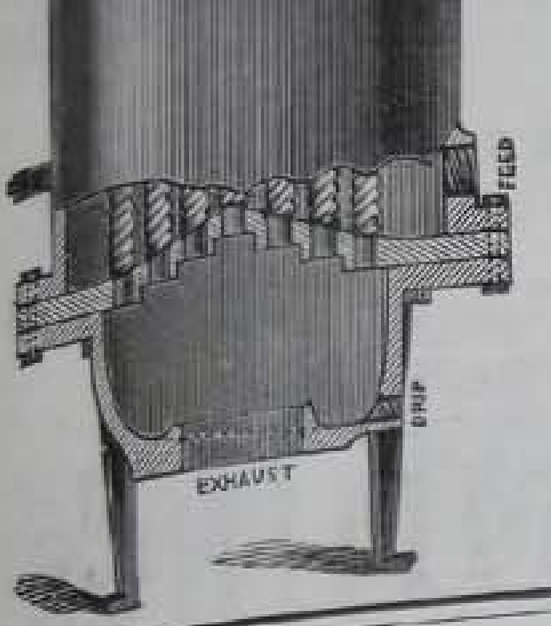


AUTON

FOR BOTH A

224 Sou

Fort Wayne "Jenney" Electr



GENERAL FOUNDRY

34 OLIVER STREET, BOSTON.

BRANCHES:

F. B. ASPINWALL, 112 Liberty Street, New York.
H. S. WALKER, 8 and 10 South Canal Street, Chicago.
FAIRBANKS & CO., Cor. Arch and Ninth Streets, Philadelphia.

J.S.CONANT-BOSTON

D. A. DANGLER, Prest. J. B. CROUSE, V. P. W. G. SMITH, Sec. and Treas. H. A. TREMAINE, Supt.

The STANDARD CARBON CO.,

CLEVELAND, OHIO,

Manufacturers of

CARBON POINTS AND BATTERY MATERIALS.

The Largest and Best Equipped Carbon Plant in the World, with a capacity of 100,000 carbons per day, making both Molded and Forced Carbons for every known system of Electric Lighting.

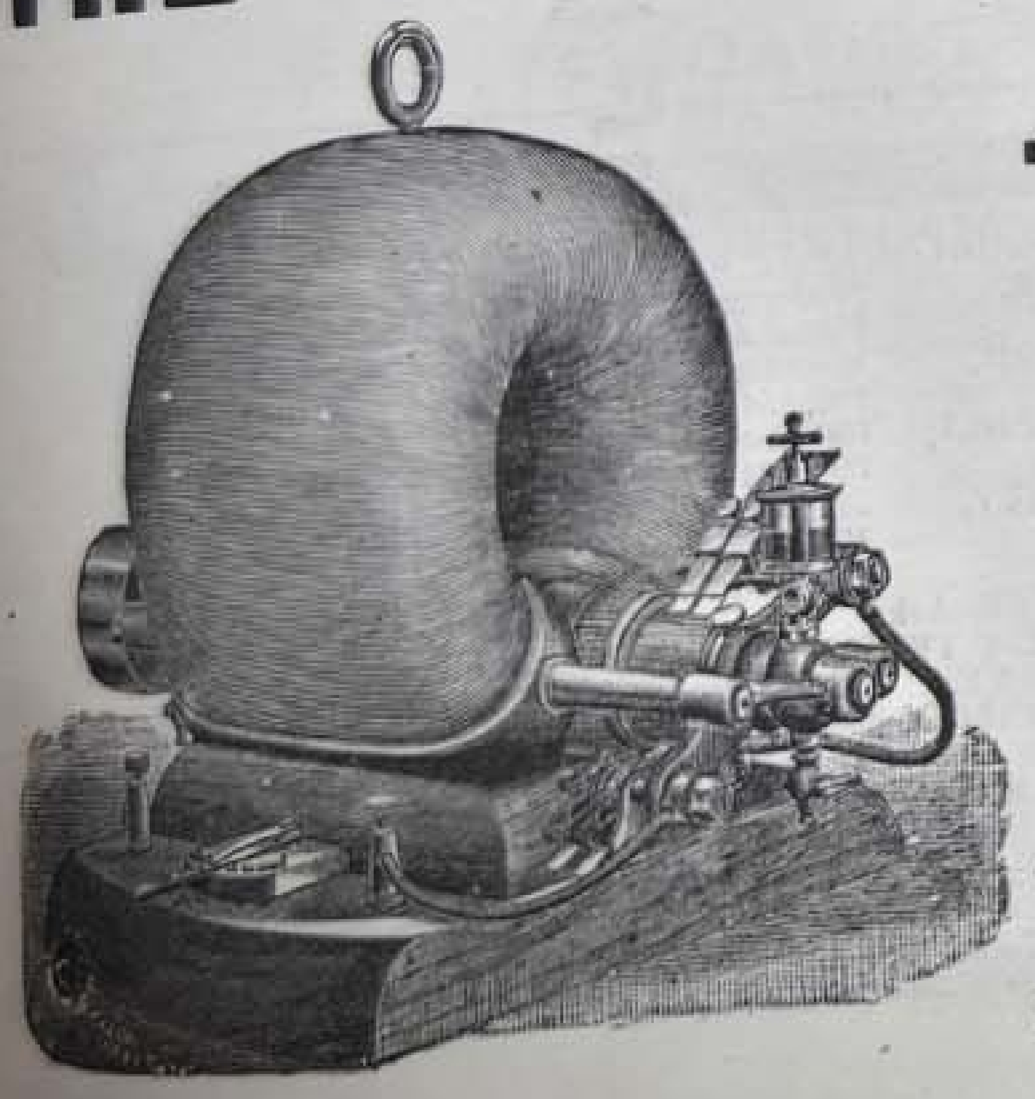
WE MAKE A SPECIALTY OF CARBON MOTOR BRUSHES IN ANY SIZE DESIRED.

THE EDDY ELECTRIC MANUFACTURING CO.,

MANUFACTURERS OF

AUTOMATIC ELECTRIC MOTORS

In all sizes, from 1-2 H. P. upward. High Efficiency, Perfect Regulation, Superior Workmanship, Ease of Management, Remarkable Simplicity, etc.



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FOR ELECTROPLATING, ELECTROTYPING COPPER REFINING, ETC.

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ARTICLE III.

How to Build an Alternating Current Dynamo or Motor. (1000 Watts.)

BY A. E. WATSON.

(Copyrighted.)

Armature Shaft and Pulleys. Procure a suitable length of 1¾-inch diameter cold-rolled steel, and turn it, excepting the 4½-inch central space, to 1⅜-inch diameter, (See Figure 8.) On the ends of this space cut threads, 16 per inch, for a distance of ⅝-inch. It is well to cut the keyway at this stage, in order that the slight springing caused by the planer tool may be eliminated by the subsequent lathe work. Let keyway be ¼x⅛-inch and begin with the threads at one end and extend into the 1⅜-inch portion about ¾-inch at the other. Turn the remainder of the shaft to the specified dimensions, fitting the ⅞-in. diameters to the bearings. Sink a ¼-inch pin in the location shown for holding the collector. Two cast iron heads are to be screwed on the threaded portions of the shaft, the laminated core of the armature being clamped between them. A detail is shown in Figure 7. First, thread the castings to fit the shaft, and surface off the spots which are to press against the sheets. It will be noticed that the outer rim is not continuous, being gashed in eight places with crescent shaped openings. Their purpose, along with the eight drilled and countersunk holes, will be explained in connection with the armature winding. Cut ¼x$\frac{3}{16}$-inch keyways across the threads. Screw one of these heads, or flanges, on the shaft next to the collector end; match the keyways, and press in a ¼-inch square key, 4½ inches long, as far as the end of the keyway in the 1⅜-inch portion of the shaft.

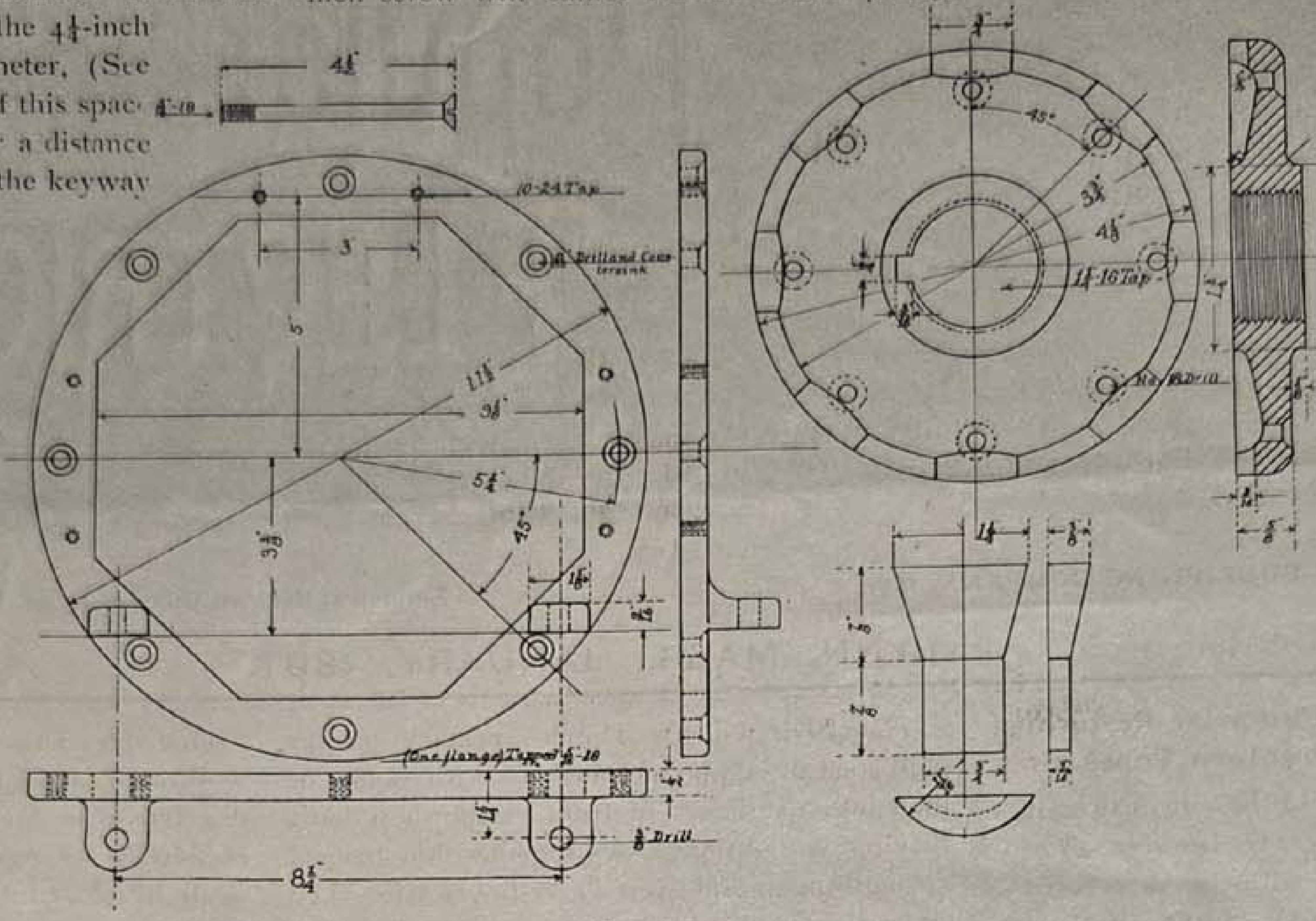

FIGURE 7.

If sheet iron for the armature core, as shown in Figure 9, cannot be procured, provide punchings six inches in diameter, with 1⅜-inch hole, and ¼x⅛-inch keyway. Clamp a sufficient number to make 3 inches in thickness on a suitably keyed arbor, and mill or saw the eight slots. Slip the sheets on the shaft, with the slots in the same location as when milled; lay a tightly fitting bar in one of the slots to keep the end punchings from turning, and screw on the other head tightly; match the keyways, and drive the key back until its ends are flush with the hubs of the castings.

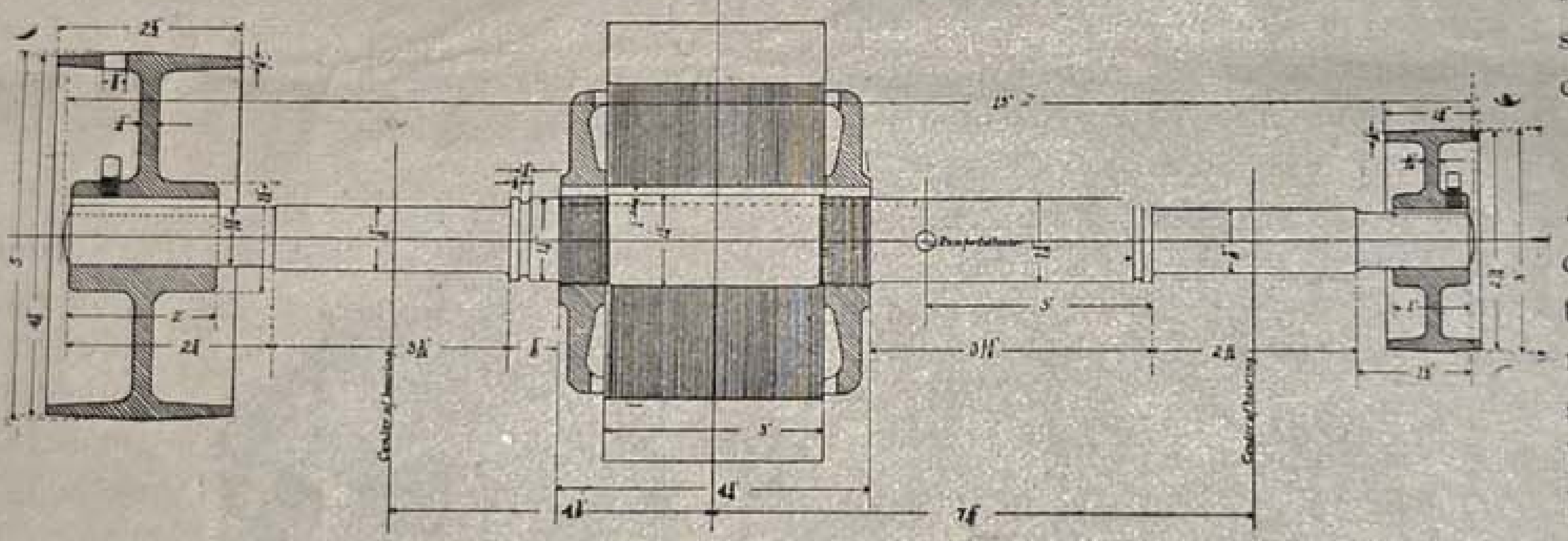

FIGURE 8.

Put the core and the shaft thus made in a lathe and take a skimming cut across the sheets to remove the slight inequalities in the surface.

The pulleys are, as usual, of cast iron, but should be turned on the inside of the rims also, so as to be balanced. A ¼-inch square key is needed for the main driving pulley, held in with a ¼-inch setscrew; but a round pin and $\frac{3}{16}$-inch screw will suffice for the exciter pulley.

Collector. This consists of two copper rings mounted on a wooden hub. Each represents a terminal of the armature winding. If seamless copper tubing cannot be procured, castings of gun metal may be substituted. Turn the rings smoothly and tap a hole with 14—20 threads in each.

Boxwood, lignum-vitæ or thoroughly seasoned maple will answer for the hub; but after turning and drilling it to the requisite dimensions, let it soak in melted paraffin for a few hours. Make two copper connectors, having the center portions threaded 14—20, one end turned to $\frac{3}{16}$-inch diameter, the other flattened and tapped 10–24. Press the rings on the hub, letting the tapped holes come over the ⅜-inch holes drilled in the wood. Insert the connectors from the inside; the small ends will drop through the rings, and may be gripped with a hand vice; screw the connectors tightly. Into them screw the long and short brass rods as shown. Solder-sweat the connectors into the rings.

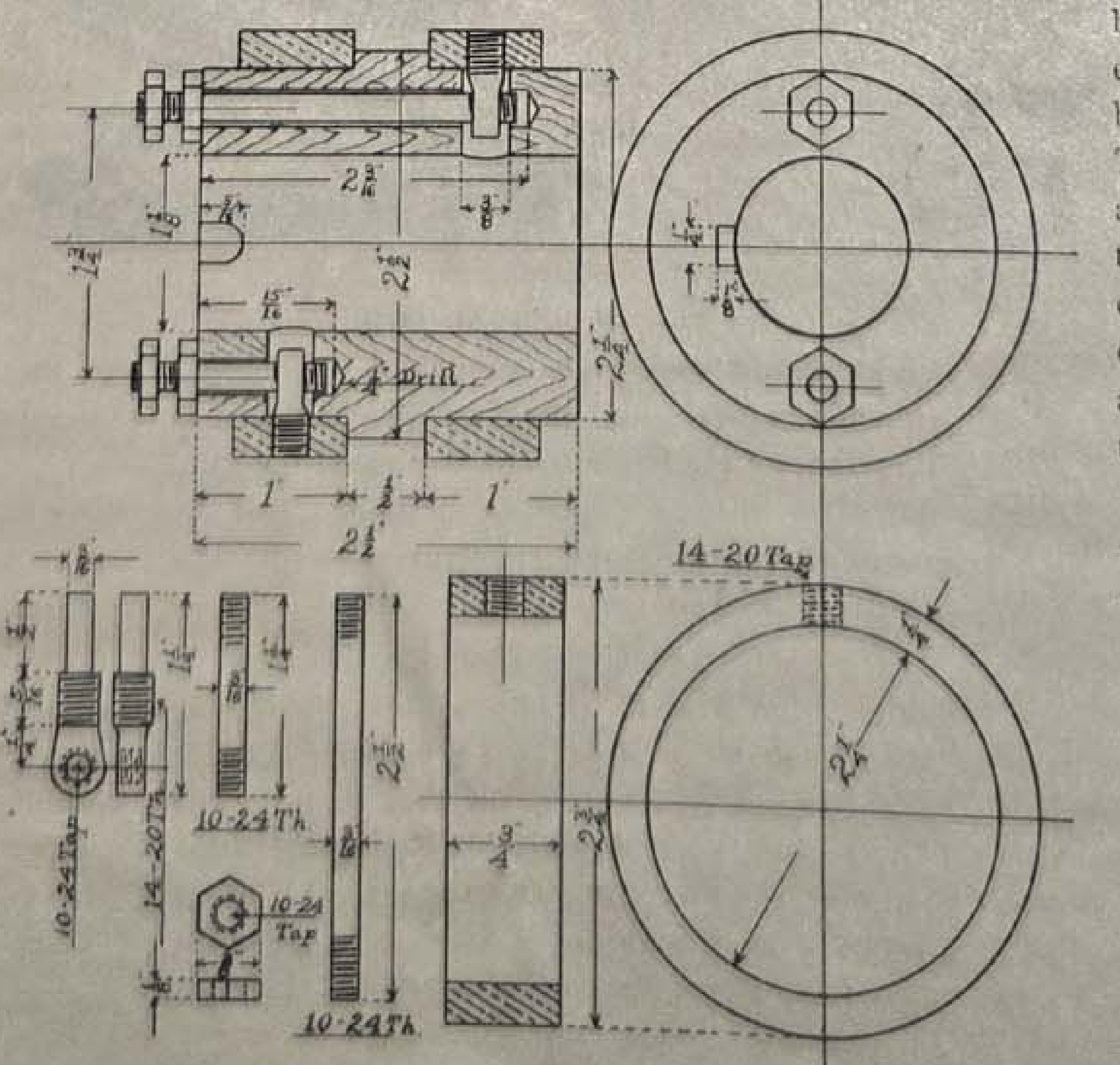

FIGURE 9.

Brushes, Holders and Studs. Copper brushes are commonly used on alternators; the continuity of the rings and the absence of sparking renders carbon brushes unnecessary. A brush and its holder is shown in Figure 10. Make the brush of thin leaf copper, cut in strips 3½-inches long, ½-inch wide and built to a thickness of $\frac{3}{16}$-inch. Solder the sheets together at one end, and bevel the other to an angle of 45°. The holder is a brass casting, having a round hole to fit the stud, and a rectangular opening for the brush. In machining, do not saw the slot until after drilling and tapping. Thumb-screws are to be made from brass rod, and the presser shoe of sheet copper.

Two brass studs are required for supporting the brush holders. These, with their insulations, are shown in Figure 11. One is necessarily longer than the other. They may be made from brass rods or castings. Hard rubber is best for the washers and bushings. On reference to Figure 4 it will be seen that the cap on the smaller bearing has two lugs projecting from one end. These are to be drilled ⅝-inch, and the surfaces faced true and the studs attached.

(TO BE CONTINUED.)

E. WATSON.

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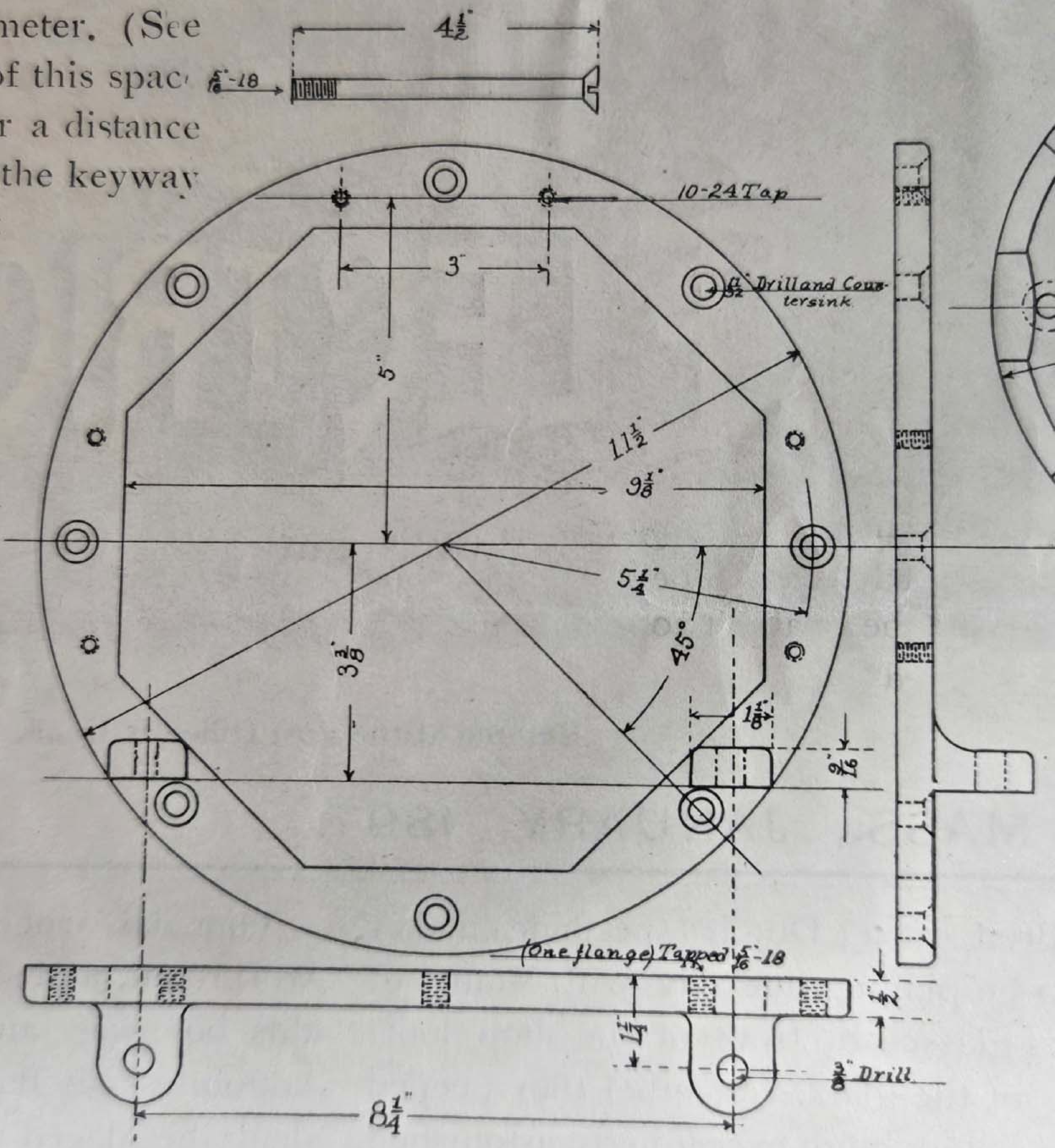
4½"
5/16"-18
10-24 Tap
3"
11/32" Drill and Countersink
5"
11½"
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5¼"
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(One flange) Tapped 5/16"-18
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3/8" Drill
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FIGURE 7.

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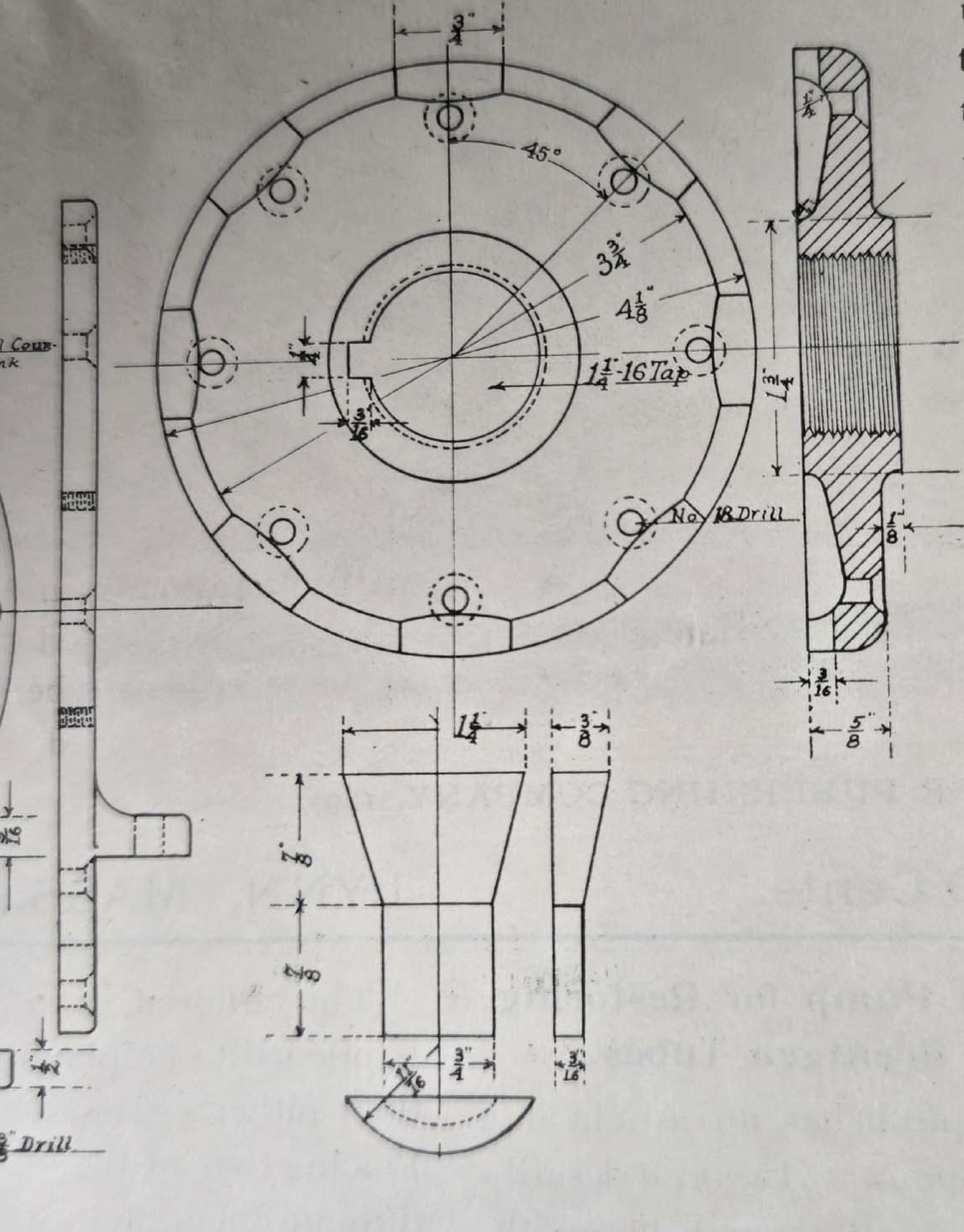

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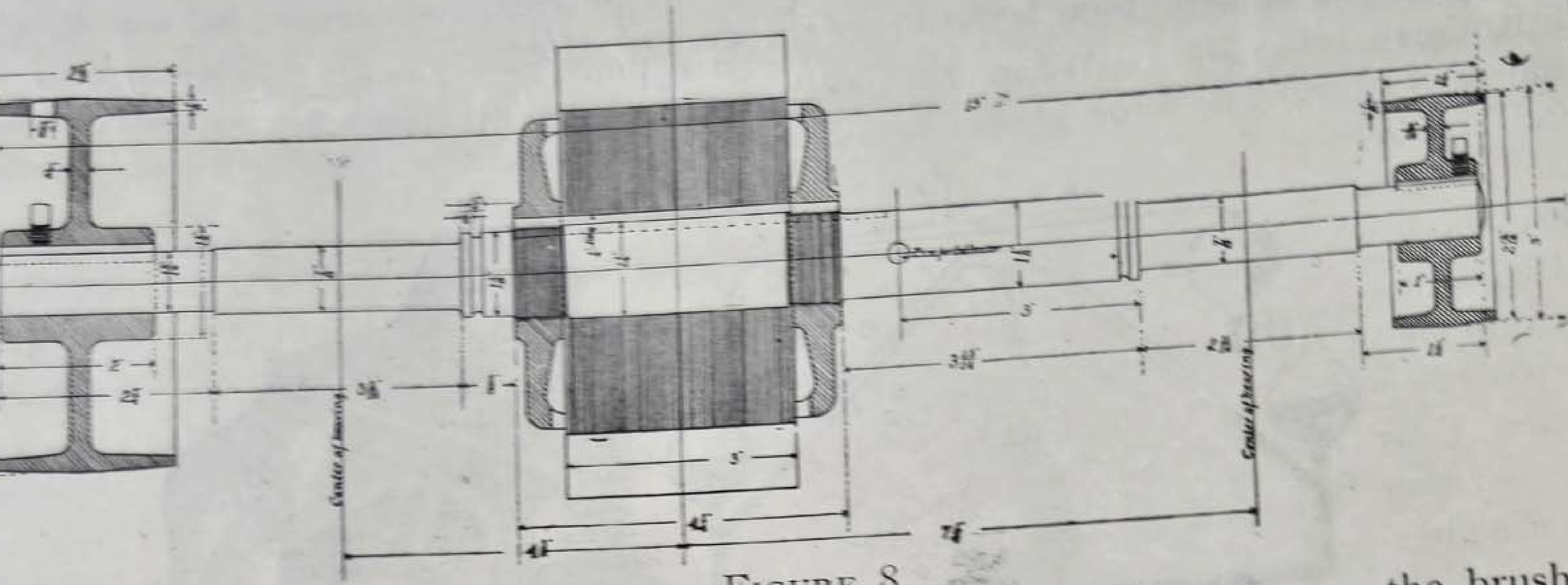
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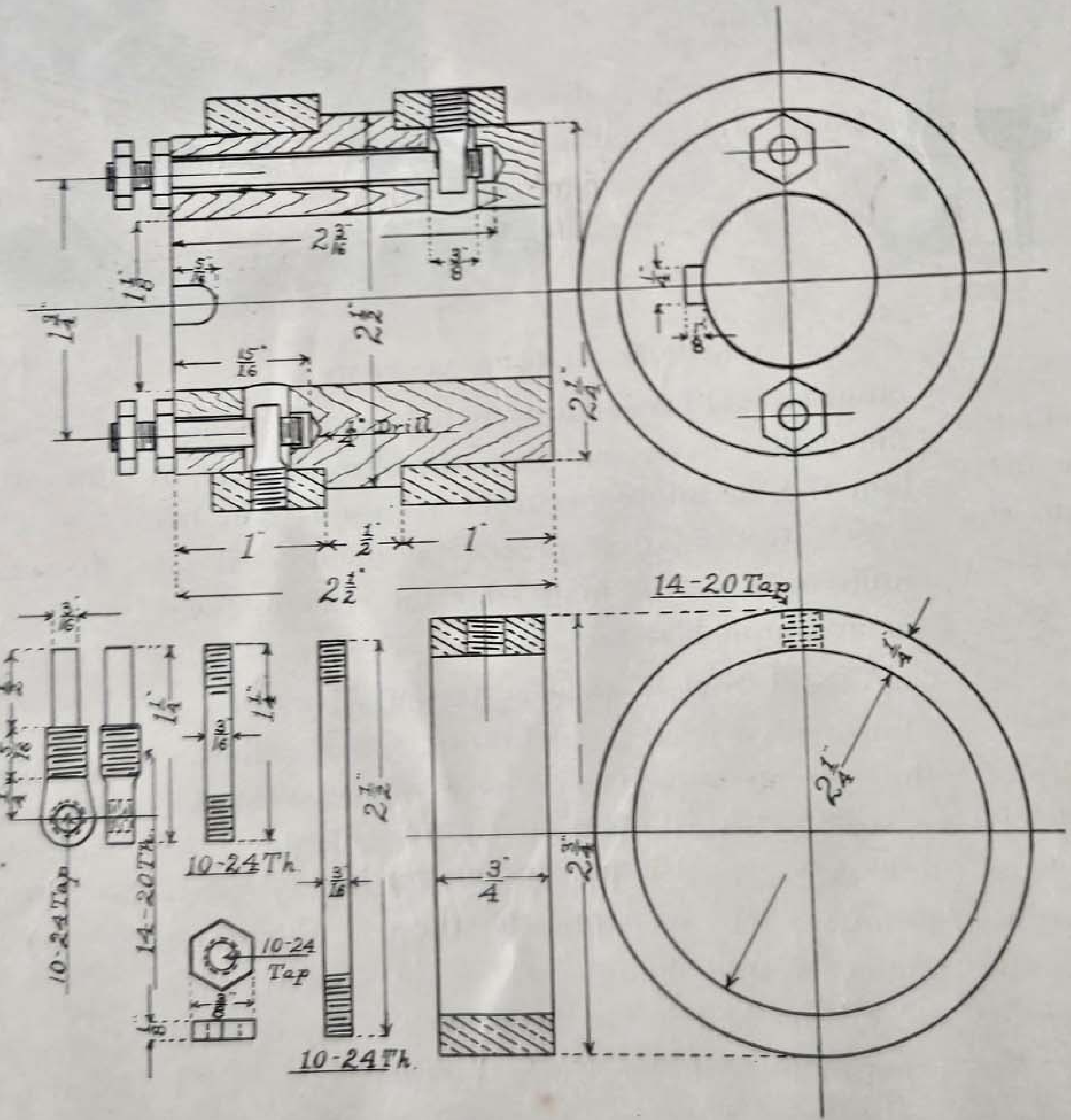
FIGURE 8.


2 3/16
3/8
1⅛
1¼
5/16
15/16
2½
2¼
¼ Drill
1
½
1
2½
14-20 Tap
¼
2¼
3/16
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1¼
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FIGURE 9.

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such mode of obtaining power would, in my opinion be no more than a mere makeshift, bound to be replaced sooner or later by a more perfect method, which implies no consumption of any material whatever.

Examination of Cathode and Roentgen X Rays through Colored Screens by the Fluoroscope.

By John Carbutt.

1. The cathode rays in an excited Crookes tube, viewed through a pale yellow screen, show increased brightness of the yellow rays.

2. Viewed through a dark violet screen, the cathode rays present a phosphorescent glow similar to that in a low volt lamp when held in the field of an induction coil.

3. Viewed through a green screen the cathode rays present to the eye a light emerald green.

4. Viewed through a dark red screen, the cathode rays present a pale red, on the carmine tint.

The screens are of thin polished plate glass, one and one-half millimeters thick, coated with gelatine, colored with aniline dyes such as I use in making my photo-chromic screens.

Examination of Roentgen rays through plain glass and the aforementioned screens shows that both cut off or absorb fully 50 per cent. of the Roentgen rays from reaching the screen of the fluoroscope. Screens of the following colors were placed side by side with the clear glass; viz., dark violet, green, light yellow and dark red, and when in juxtaposition, it was impossible to recognize which was clear glass and which was colored, and the eye was unable to detect any color sensation when looking through the fluoroscope with the colored screens in close contact.

These experiments confirm me in the opinion I have held from my first dealing with the Roentgen X Rays, that they are of the ultra violet, because I find they absorb the entire spectrum, while a deep violet screen absorbs all but the red.

It was very early determined by Prof. Roentgen that the X rays could neither be deflected or refracted, and I am not aware of any experiments having been made to determine the absorbtive powers by the X rays of the colors of of the spectrum.—*Electrical Review.*

The Lampist Discovered.

An "assistant lampist" is about to be chosen for the postoffice building. As indicated by his

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REMEMBER all subscribers are invited to use our Correspondence column free.

NEW BOOK.

Lord Kelvin's Discussion of Edward P. Thompson's Book on Roentgen Rays.

I received it only a few days ago, but I have already looked nearly all through it with great interest. I have seen enough to know that I shall find much most useful information in it which will be always readily available, because of the very excellent method and care with which you have given references to authors, dates and publications, and I am sure that all who are interested in the subject will find your book exceedingly valuable.

All your statements with reference to anything I have done on the subject are perfectly correct.

I believe that hitherto nothing in the way of diffraction has been discovered for the Röntgen rays.

NEW PATENTS.

571,600. Controller for Electric Pumps. Frank W. Merritt, Duluth, Minn. Application

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Something About The Crookes Tube.

BY EDWARD TREVERT.

The Crookes tube is a necessary adjunct to the production of X-Rays. It consists of a thin glass globe or bulb into which is fused through the glass two platinum electrodes, one for the anode and one for the cathode. The anode is the point where the current enters the tube. The cathode is the point where the current leaves. Hence, either electrode of the tube may be made the cathode, by simply reversing the direction of the current. A good tube not more than two inches in diameter and with the elctrodes inside, not over an inch apart, with a coil giving a spark one and one-half inches, will make fairly good shadow pictures, if the exposure is long enough. If a larger tube is used the coil should give a spark from three to ten inches. By this we mean that the secondary current should jump in the air the distance between the electrodes of the coil the above number of inches. If there is a blue glow that shows in a tube it will not produce X-Rays. What light there is to be seen should be a green color. The glass bulb is exhausted of nearly all air and gases making nearly a perfect vacuum. This vacuum differs from that in an incandescent lamp or a Geissler tube, viz.: It is so complete that only about one millionth of the original quantity of atmosphere remains in the Crookes tube, while the lamp or Geissler tube contains one-thousandth or more. When a high potential intermittent or alternating discharge from the induction coil is sent through the Crookes tube there appears in the tube a fluorescent light of a yellowish green color. These rays are particularly strong around the cathode and are called cathode rays.

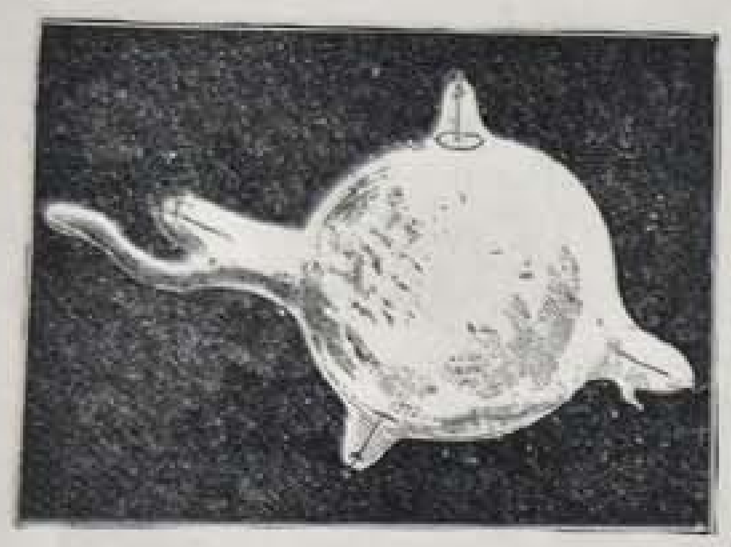

FIGURE 1.

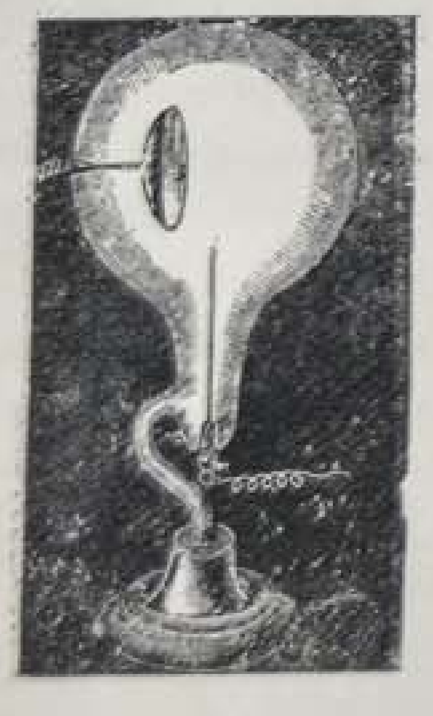

FIGURE 2.

Several important facts about the Crookes tube will bear mention here. First it must be made of the thinnest glass possible and be sufficiently strong to stand the pressure of the atmosphere. A tube made of thick glass will heat to a high temperature, while a tube made of thin glass remains quite cool under the influence of the discharge. Thick glass is more highly fluorescent but is greatly inferior to thin glass in radiographic power.

When tubes are made of glass containing lead they show a blue fluorescence under excitation; hence such glass should not be used. A suitable glass gives a green fluorescence.

The size of the tube should be considered. If sharpness of detail is desired, the tube should be small. Some of the best shadow pictures have been made with small tubes. Up to the present time there has been shown no advantage in using a large tube. Small ones when properly excited seem to be as powerful as large ones and have the advantage of giving clearer definition. Another advantage of the small tube is that the short distance between the terminal permits the use of a small induction coil and less battery power. It is therefore desirable for amateurs who have limited means to spare. The degree of vacuum is an important factor. To every degree of vacuum there is a corresponding electrical excitation which gives the best results. Highest vacua are not desirable. There is a degree where superior results may be obtained. After a tube has been excited continuously for some time the vacuum will rise; by increasing the excitation proportionally the Röntgen effect will improve until the excitation is at its limit, when the tube may be brought back to its range by gently warming it in the flame of an alcohol lamp or gas burner.

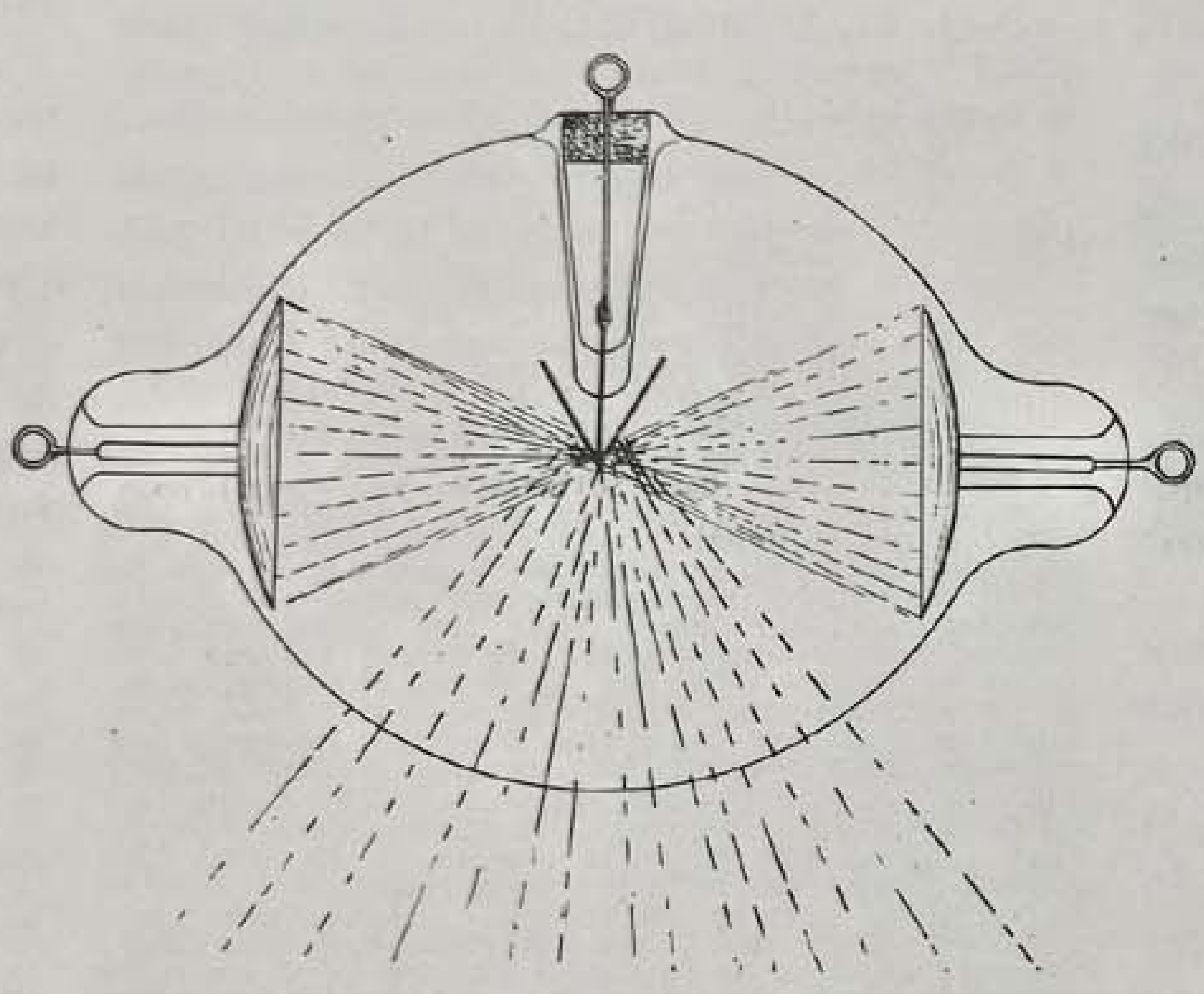

FIGURE 3.

One of the latest theories of the X-Rays is that they emanate from the surface or surfaces that are first impinged upon by the cathode rays which proceed from the negative electrode of the Crookes tube. The generating surface is often the anode. They are generated by a bombardment of cathode rays against a glass of metallic surface. The metallic surface seems to be the most powerful source and platinum the best of metals. Hence the use of reflectors in Crookes tubes.

Prof. Crookes was the inventor of this tube, hence the name. They are made in various shapes; two forms are shown in Figs. 1 and 2.

[*] *A Proposed Standard Tube for Producing Roentgen Rays.*—The observations which have up to this time been made as to the source of Röntgen rays point to the fact that the cathode rays must strike some surface which then becomes the Röntgen ray source. My own observations make me think that if the bombarded surface is of such a dense metal as platinum, which does not fluoresce, the rays will be more energetic. Bearing in mind these observations, and the fact that it is desirable to possess Crookes tubes which are of standard make, and adapted for use with high frequency apparatus, Ruhmkorff coils with oscillatory or uni-directional discharge, or with Wimshurst or Holtz machines, I have proposed as a standard tube one which is represented in the accompanying illustrations. (See Fig. 3.)

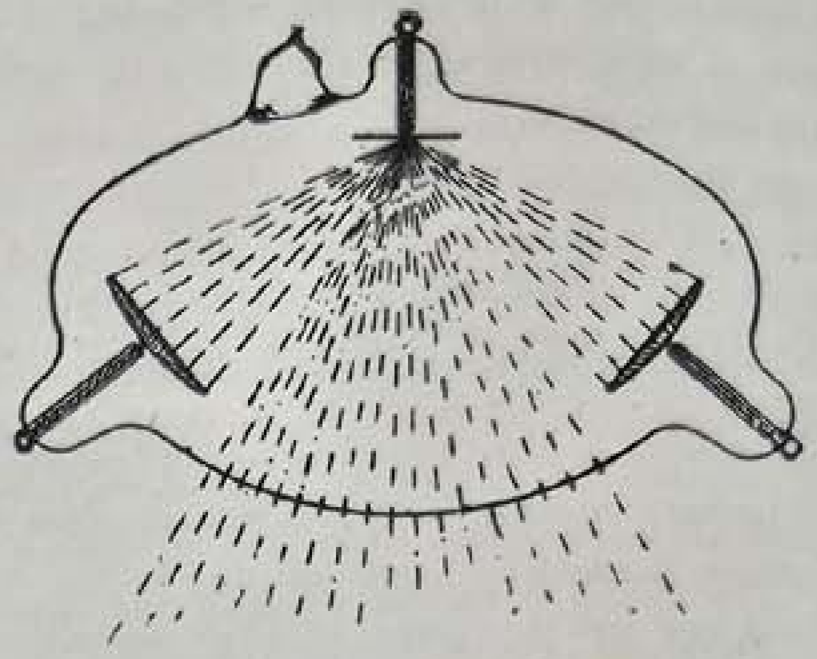

FIGURE 4.

The structure consists of a bulb, at opposite sides of which are mounted concave aluminum discs supported on wires sealed through the glass. The foci of these concave electrodes coincide nearly at the center of the bulb, at which point is located a V-shaped sheet of platinum, iron, a small piece of iridium, or other piece of metal. This could be supported in any way desired, but it may be suggested, as a convenience, that it be mounted on a third or middle terminal, so that it can be made an anode. In using this tube with high-frequency currents the two cup-shaped terminals are attached to the source of electric currents, which alternately become cathode during the discharges and cause the Röntgen rays to be emitted from the apex of the platinum sheet or from the surface of the piece of metal placed at the common focus. With oscillatory currents from a Ruhmkorff coil the same connections may be used, and even when the discharges are uni-directional the connection of either cup-shaped terminal as a cathode makes the tube effective, but in this case the middle terminal may be made the anode and the other or cup-shaped terminal a double cathode, and thus give the greatest amount of cathode surface with but a short distance to be traversed by the discharges, while the sharpness of the focus, and, consequently, the definition obtainable with the Röntgen rays, remains unimpaired. If the vacuum in such a tube is too low, it is also possible to raise it quickly by constituting the middle terminal a cathode for a time, in which

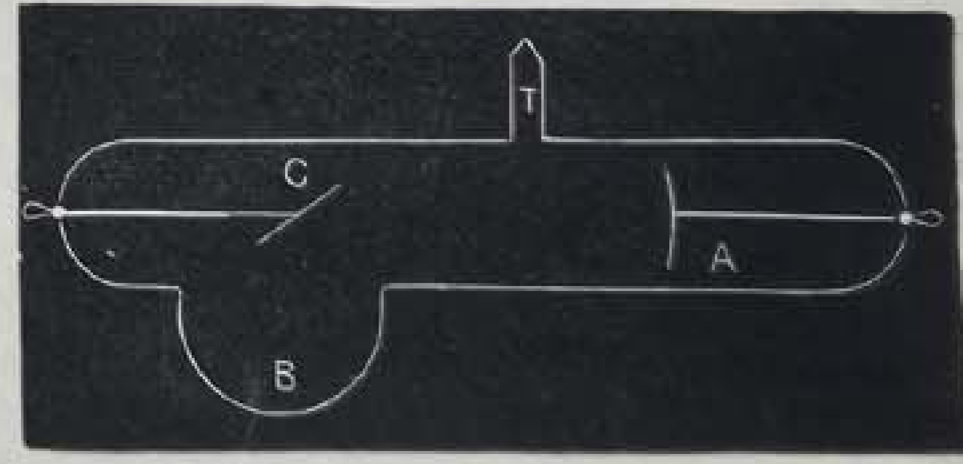

FIGURE 5.

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[*] Elihu Thomson in the *Electrical World*.

case metal would be carried therefrom and deposited on the side of the bulb in a very fine state of subdivision and quickly absorb the residual gas. If during the working of the tube the vacuum becomes too high it can sometimes be reduced by simply heating the tube to a high temperature.

**Focusing Tube For Use With Alternate Currents.*—In Professor Röntgen's second communication to the Würzburg Physico-Medical Society, he states that he is constructing a special form of vacuum tube for use with alternate currents from a Tesla transformer. For those whose laboratories are supplied with alternating current, but who cannot readily obtain continuous current, a tube suitable for use with Tesla current is an advantage. The illustration (Fig. 4) shows such a tube which I had made nearly two months ago. The two curved aluminum discs serve alternately as cathode and anode according to the direction of the current, each focusing its cathode rays upon an identical portion of the flat platinum reflector. If carefully made, so that the foci of the two discs are exactly in the same point, the tube will be found to work well.

By connecting both discs together and using them as cathode, and employing the platinum as anode, the same tube will answer for Ruhmkorff currents.

†*Improved Crookes Tube.*—At Bowdoin College a long series of experiments has been in progress with a view to improving the Crookes tubes.

They have made and tested every shape and variety that seemed to give any promise of success, and are convinced that the ordinary spherical or bulb form is about the worst possible, while a comparatively small tube has so far given the best results.

The window intended for the passage of the rays must be as thin as possible, because glass, as is well known, is more or less opaque to them. At the same time it must be thick enough to bear the pressure of the atmosphere when the tube is exhausted.

Of all the forms of tube that we have tried, the one shown in Fig. 5 is the most effective. Here the anode, C, is an inclined plate of thin platinum. This is placed at or beyond the focal point of the cathode, A. This piece of platinum becomes red hot, and is, as far as can be judged, the source of the ray. It is a curious fact that the anode, C, if made in the form of a thin plate, may nearly fill the tube without in any way obstructing the passage of the rays out at the bulb. The bulb is filled with an intense green fluorescence, and sparks can be drawn from it by approaching the finger.

Not only do these tubes give remarkable results in the way of intensity of rays, but also extremely fine definition.

The cellular structure of the bones is clearly brought out and the course of the tendons can be traced along the arm. Good pictures of the bones of the fingers can be obtained in from five to thirty seconds, and of the hand and wrist in from one to ten minutes.

Odd Causes of Electrical Fires.

From the quarterly report of the Electrical Bureau of the National Board of Fire Underwriters, we learn of the following odd causes of fire. A plush curtain in a theatre, on being hoisted, came in contact with a 32-candle power incandescent lamp. The common size is 16-candle power. The heat from the lamp ignited the curtain, but the fire was discovered, with no loss, except the curtain.

A stage hand was ordered to turn out an incandescent lamp, and not knowing how to do it, instead of turning the switch, wrapped a damp towel around the bulb. Some time afterword the towel was discovered smouldering.

A portable incandescent lamp was allowed to remain lighted lying on a mattress. The heat from the lamp ignited the cloth and the excelsior of the mattress, and the fire spread through the basement and store.

An electric pressing iron was allowed to stand with the current turned on. The heated iron after a time set fire to the table, and the flames communicated to the surrounding combustible material.

A wagon loaded with gasolene collided with an electric car. The wagon was demolished and the oil flooded the street. The accident attracted the attention of the motorman of another car, who ran his car up to the scene. Seeing the oil running under his car, he turned on the current to get away. A spark from the wheel immediately ignited the gasolene fumes and instantly the street was ablaze. Four people were injured, one seriously, and one horse was burned to death.

Fire occurred in a basement, owing to dripping water falling on an electrical measuring instrument, thereby short circuiting it. No damage was done beyond the loss of the instrument.

Sparks from arc lamps in a department store ignited cloaks on a table underneath.

An elevator motor was burned out, having been left running when the employes left the store, the motor brushes having been badly adjusted.

A carpenter dropped a nut on the coils of a rheostat, short circuiting them with an iron frame resting against a gaspipe. An arc was formed between the frame and the pipe; the latter was melted and the escaping gas ignited. but small loss occurred.

Rats gnawed the insulation from a wire which lay on a gas pipe; an arc was established between the wire and the gas pipe setting fire to the gas.—*New Ideas.*

Government Telephone Service In England.

[London Correspondence to the New York Sun.]

There are signs of a coming telephone revolt in England—not against the National Telephone Company, which owns and operates the local exchanges in Great Britain and Ireland; but against the government management of the trunk lines. The biggest job in Parliament during recent years was the passage of the bill for the purchase of the telephone trunk lines by the government. This branch of the telephone business proved utterly unprofitable to the National Telephone Company. The corporation succeeded in unloading the service upon the government at a scandalously high price. It was assumed, of course, that if the government could operate a postoffice and telegraph system it would certainly be able to manage a telephone service efficiently. Experience thus far shows just the contrary.

The inter-municipal service, when the lines were under the control of the National Telephone Company, was prompt and satisfactory. Then the service between towns was comparatively simple. Two subscribers in different towns were put into communication directly through their respective local exchanges. Now if a man in London wishes to speak with a man in Liverpool he calls up his own central office and makes known his desire. The operator there transmits the request to the general postoffice in London. That office, when it gets ready, communicates with the general postoffice in Liverpool, and thence to the local telephone exchange in the latter city, and finally the desired subscriber is reached. Under the old system such connections did not require over two minutes. The government seems unable to accomplish it in less than 25 minutes, and often a much longer time is occupied. It is even of recent record that a call for a subscriber in another town given at 10 o'clock in the morning was not put through until 4.50 in the afternoon. No explanation or excuse for this practical paralysis of the telephone system under government management has ever been given.

The telephone has by no means become the almost universal and popular institution in England that it is in most countries. It is not possible in London, for instance, to call up your butcher, grocer, doctor or friend on the other side of town, as may be done in most small villages in the United States. It will come eventually, no doubt, but English conservatism is too strong for any such sweeping concession to progress within another half generation or so.

At the meeting on December 14 the Chicago City Council, by a vote of 63 to 3, passed the ordinance directing the street railway companies of the city to sell tickets good for six rides for 25 cents, 12 for 50 cents and 25 for $1, under a penalty of a fine not less than $5 or more than $25 for each offense. There was some parliamentary sparring before the ordinance was put to final passage, but the friends of the measure were in a large majority (although not so large as indicated by the final vote, when many opposing aldermen "climbed into the band wagon") and easily defeated all motions to amend or refer. The ordinance, at this writing, is in the hands of the mayor. If he signs it there will undoubtedly be a long contest in the courts, as Alderman Gallagher, who introduced the ordinance, admitted that the companies would carry it to the court of last resort. Alderman Fitch, who voted against the ordinance, said he was heartily in favor of low fares, but that he conscientiously believed that an ordinance which specifically named a five-cent fare was a contract between the city and the street car companies, and he did not believe any city council could rightfully break a contract when the other party to the contract was carrying out its end of the bargain.

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*By A. A. Campbell Swinton.

†By C. C. Hutchins and F. C. Robinson, Bowdoin College Sci. Am.

Brief History of Electricity and Magnetism.

BY E. T. BUBIER, 2d.

Discovery of Electricity.—The statement is made in early writings that workmen engaged in polishing amber, which was highly prized by the ancients as an ornamental gem, were seized with violent tremors in their arms, an exaggerated account of which might have occurred from rubbing the substance. For several centuries this suggestive experiment was forced to stand alone, without any attempt to to investigate.

Discovery of Magnetism.—Flavie Gioja who lived in 1300 gave the first real distinction and value to the peculiar property of the lodestone. He discovered that if a piece of iron was magnetized—which he could do with his lodestones—and suspended from its middle in a balanced condition, one end always pointed in a certain direction, which direction was north. Deeply interested in this strange phenomenon, he finally took a needle, fastened it upon a card, which was marked "north," "south," "east," and "west," attached this to a cork and floated it in the center of a basin of water. He then turned his basin and noted that no matter what its position, north always pointed in the same direction.

Early Discoveries.—Dr. Gilbert published his work entitled "De Magnete" in 1600, and shows that many substances besides amber possessed magnetic attraction.

Otto Von Guericke—made the first electrical machine. It was a ball of sulphur, so attached to a revolving part that when a crank was turned the ball revolved; when a hand or some other substance was held against the sulphur it became electrified.

Sir Isaac Newton—made some very valuable discoveries.

Benjamin Franklin,—born 1706, made some valuable discoveries and among other things proved that there was no mystery about electricity; that it was not created but existed everywhere and was simply collected. His well known experiment with the kite, where he succeeded in collecting a discharge from the clouds in a thunder storm, is familiar to everyone.

Galvani,—born in 1737, discovered a new source of electricity in the twitching of a frog's leg. The story is well known and was mere accident. He tried all kinds of experiments and his deductions were soon made known to the whole world.

Volta,—was one of the many scientific men who was attracted by Galvani's discoveries. He immediately instituted a series of experiments. He found that two different metals were essential in the production of the new electricity, and he constructed the voltaic pile, which was composed of silver coins and pieces of zinc, with moistened paper placed between them; with this he found it possible to produce all the effects of electricity which were produced by friction on glass, amber or sulphur. He very soon improved the pile by substituting metal strips in cups of acid water which constituted the first voltaic battery.

Davy,—about 1808, constructed a large number of cells (about 2,000) and connecting them together produced the first electric light. He used two pieces of charcoal for his lamp, brought them together and then separated them, thereby producing an arc. In 1820 he independently discovered the magnetising effect of the electric current on steel and iron, and one year later described how the electric arc may be deflected by a magnet.

Oersted,—while experimenting in 1819 discovered the deflection of the magnetic needle, when a wire carrying a current was brought near and parallel with it; this was the first knowledge of electro-magnetism.

Ampere,—was born in 1775. He studied Oersted's discovery and propounded the theory by which all magnetic phenomena can be explained. Instead of the fluid hypothesis, he assumed that each individual molecule of a magnetic substance is traversed by a closed electric current, and that these molecules are free to move about their centers. The natural condition of this iron tends to keep these molecules in a certain position, whereas the influence of the electric current tends to so rotate them that the closed electric current of each molecule lies parallel with the main current. The difference between steel and soft iron is easily explained. Steel being denser, the molecules are closer together and harder to rotate, therefore, once rotated the longer the reverse action is taking place and the longer it retains its magnetization. With soft iron the molecules are freer to rotate, hence it is more easily magnetized and loses its magnetism more quickly.

Sturgeon,—constructed the first electro-magnet. He wound several turns of bare copper wire upon a bar of iron, simply insulating the bar and winding the wire upon it.

Henry,—discovered that the magnet could be made more powerful by putting more wire on it and insulating the wire by wrapping it with cotton or some other material. He made some very powerful magnets in this way. In 1831 he built an electric motor. This motor is well preserved and can be seen at the present day at Princeton College.

Faraday,—born 1791. He began his work in 1825. Faraday knowing that magnetism was produced by electricity, attempted to produce electricity from magnetism, and in his original experiment he used an iron ring on which was wound two separate coils of wire, to the terminals of one coil he connected a battery, and the terminals of the other coil were connected to a galvanometer, which as I have already explained, will detect the presence of a current of electricity. A coil of wire consisting of a few turns, the ends of the wire connected to the reflecting galvanometer, will also illustrate what is meant by induction. Whenever the bar magnet is moved towards or away from the coil, the spot of light is seen to move to the right or to the left as the case may be, and is only momentary, lasting during the time of movement. Let the magnet be fixed and the coil of wire moved and the same results are obtained.

All that is necessary in producing a current of electricity is that some change is made in the coil of wire or in the magnetic atmosphere in which it is placed. In other words, whenever the number of lines of magnetism or lines of force threaded through a coil of wire is made to vary, then there is produced in the coil a current of electricity. The model of the first dynamo machine that was ever made involves this principle, and the original was invented and manufactured in a single day by Faraday. It consists of a copper disc so mounted that it can be revolved between the poles of a magnet; the axis and edge of the disc constitute the terminals and are connected to the galvanometer; on turning the disc the spot of light moves across the screen showing the presence of a current of electricity. This then is the parent of all dynamos that are today producing the electric energy which floods with light all the civilized towns and cities of the world.

Barlow,—made his rotating wheel in 1823. He made his spur wheel in 1826; and with it he obtained an electric current.

Pixii,—constructed a magneto machine in 1832. It was a practical machine. It consisted of a horseshoe magnet, under the poles of which a powerful steel horseshoe was rotated on a shaft. On the steel horseshoe was coiled a wire, and as the ends of the horseshoe were moved up to and removed from the poles of the magnet, electric currents were produced in the coil.

Jacobi,—designed a motor in 1834; it consisted of two sets of electro-magnets with their poles facing each other; each set comprised four magnets, one set was fixed the other revolved. By the means of a commutator the polarity of each magnet on the revolving frame was changed just as they faced the magnets on the fixed frame.

*"*Wheatstone,*—in 1841, constructed the first continuous current dynamo. This machine had five armatures, each consisting of a pair of short parallel cylindrical coils with iron cores, and each having a simple split commutator. These armatures were arranged in a row along a single shaft with six compound steel magnets between them. The five armatures being so set that they came successively into the position of the greatest activity, no two of them being commuted at the same instant. They were connected in series with one another by wires, which joined the positive brush—a brass spring—of one to the negative brush of the next." Four years later Wheatstone and Cooke patented the use of electro-magnets instead of permanent magnets in such machines.

Elias. Constructed a motor in 1842, so designed that it utilized the action of parallel currents.

(TO BE CONTINUED.)

Electricity has been tried on the Manhattan Elevated Railroad in New York, on a small branch line between 23d st. ferry and the 3d ave. main line. A third rail at the side of, and 10 inches higher than the other rails, carries the current, which is taken off by means of two sliding steel shoes. The motor-car carries, when fully equipped, a storage battery of 250 cells, which can be used on emergency, and which serves to keep the load on the line and the station fairly uniform. The battery is capable of working the train by itself.

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*Thompson's Dynamo-Electric Machinery.

Telephone Currents.

BY J. POOLE.

Underground Work.—The principal objection made to underground lines is the increased cost of installation, but it appears certain that the diminished cost of maintenance of a good system would soon counterbalance this. A more serious objection is in regard to the increased statical capacity, which seriously affects long-distance working. The main point, therefore, in regard to the design of cables for the work is to ensure that the capacity of the wires is kept as low as possible.

On account of the great number of different forms of cable used in America, a conference of leading experts has met yearly since 1889 to confer on the best type of cable for underground work. The following are some of their latest suggestions, and constitute what are called *dry-core cables:*—The cables should be made up of copper wires of not less than 98 per cent. conductivity, .035 in. diameter, twisted in pairs, each twist to be complete in about 3 ins. Each wire to be covered with some dry material, as cotton or special paper, to a diameter of .125 in. These pairs of wires to be put up in layers laid in opposite directions.

The cable thus formed to be enclosed in a pipe made of 97 per cent. lead and 3 per cent. tin, this alloy being used to resist the injurious action of creosote. The tube to be .125 in. in thickness and of a maximum outside diameter of 2.25 ins. The pipe to be covered with asphaltic paint, two coverings of braid or tape saturated with asphaltic paint, and a final coating of powdered soapstone to facilitate its drawing through the ducts. The inductive capacity of each wire after laying not to exceed .085 mf. per mile, and the insulation not less than 100 megohms.

Several cables have been made by different firms conforming to these requirements but differing in details, the chief endeavor being to get as much air space as possible between the wires, as air gives the least capacity.

To maintain their efficiency it is necessary to keep the insides of these cables very dry, so that the jointing, etc., must be very carefully and quickly done, or the damp of the atmosphere will be drawn in at the ends. To prevent this as much as possible, the Western Electric Company plug-up the ends of their cables for a few feet with a mixture of paraffin and air or carbonic oxide gas (as they formerly impregnated the whole length of their *Patterson* cable), thus securing very good insulation with the lowest capacity, which, in a 50-pair cable, only amounts to .07 mf. per mile. The wires in this cable are covered with prepared paper, which has been crumpled (by passing between rollers), thus providing a good air space round the wires.

In the "Norwich" Conference Cable the nsulation consists of several layers of a special paper, which gives very high insulation, but ot quite so low capacity as the Patterson. This cable is also made in this country by the ritish Insulated Wire Company, and a similar ne to the following by the Fowler Waring ompany.

The "Brooks" Conference Cable.—In this, the wires are covered with layers of prepared paper, laid on and crumpled longitudinally. This is kept in place by winding over it a few threads of cotton. The capacity of this cable is also about .07 mf.

The above cables have now replaced others in which cotton-fiber wound on the wires was impregnated with various oils, such as pyroligneous, as formerly used by the Faraday Electric Company; and resin oil, as used by the Brooks Company, which, although very effective in keeping out moisture, gave a higher capacity.

Conduits.—Receptacles for the cables, called *conduits*, are constructed under the roadways, generally close to the curbstones, and are of several types. Three types appear to have turned out most successful in America.

1. *Creosoted Wooden Blocks* are laid in cement, some 3 or 4 ft. under the roadway, having holes about 3 or 4 in. dia. for the reception of the cables. Such conduits appear to have stood the test of experience very well, the only trouble with them having been an injurious action of the creosote on the lead tubes. The alloy of lead and tin recommended by the Conference completely withstands the action.

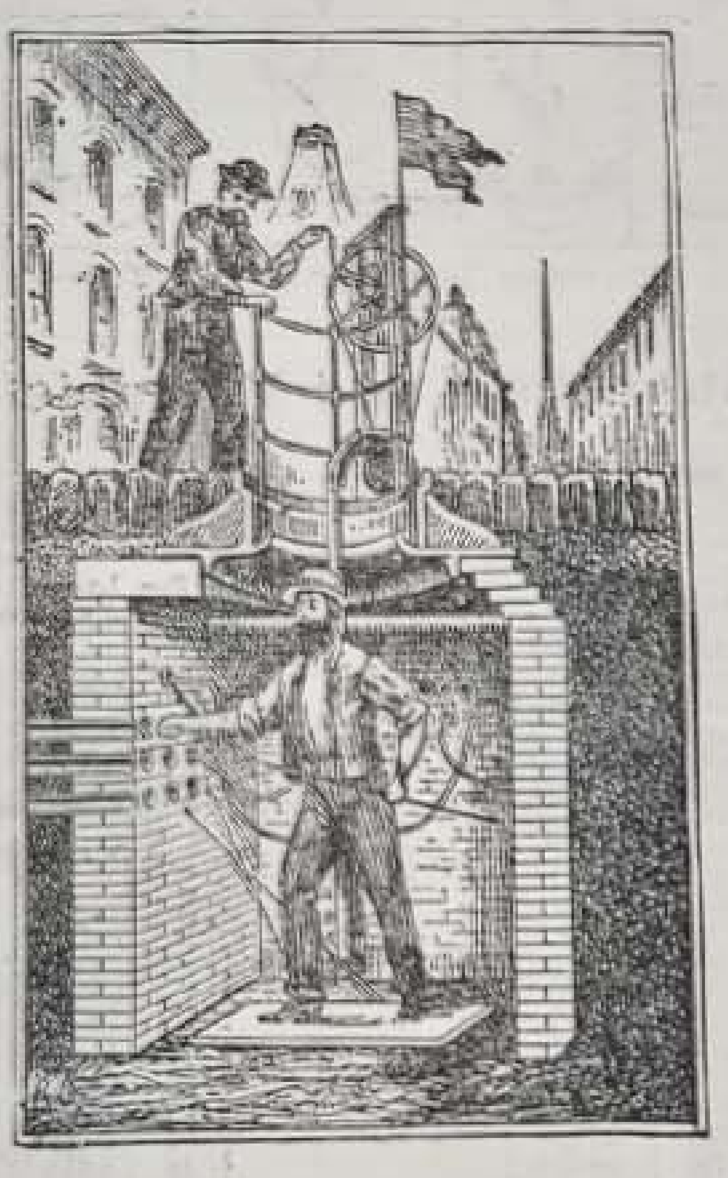


FIGURE 1.

2. *Cement-lined Pipes.*—These are constructed as follows: A sheet-iron tube, 8 ft. long, is held vertically. Inside this is placed a smaller brass tube, and semi-liquid cement is then poured into the space between the tubes. When the cement has solidified the brass tube is withdrawn, and the tube, with others, is then fixed underground in a bed of cement, the tubes being connected in lengths by means of a kind of ball and socket joint. *Ducts*, as they are called, formed of these tubes, appear to be rapidly increasing.

3. *Wrought Iron Pipes.*—This appears to be the most successful form of duct. The pipes are 20 feet long and .217 inches thick. In laying them a trench is dug about four feet deep along the side of the street. A layer of hydraulic cement concrete is then laid and rammed on the bottom. On this is laid a row of iron pipes, side by side. On these another layer of concrete, then another set of pipes, and so on until there are sufficient ducts, a thick cover of concrete being laid over all. The pipes are joined end to end by a coupling screw joint, so than they can be quickly put together. The inside of the tubes is often asphalted to prevent rust.

Manholes.—In order to place the cables in the ducts and to make the necessary connections to them, manholes are provided along the route. Along the principal conduits these are generally constructed of brickwork, well cemented to render them water-tight. They are made about 6 ft. square and from 5 to 10 ft. in depth, at distances of about 70 yards apart. Figure 1 is a section of a manhole, showing the iron casting which is placed over the brickwork, reaching to the level of the roadway. To this are fitted two round or oval covers, one large and heavy at the street level, and the other, a smaller one, below, the latter being made to fit closely by india-rubber on to the ledge of the casting, so as to render the manhole perfectly water-tight.

Ventilation.—The great trouble with the underground system is not with water, but from coal gas, which leaks from the mains and finds its way into the conduits and manholes, forming, with the air, a dangerous explosive mixture. Many serious explosions have occurred by the gas becoming ignited in some manner. To prevent the accumulation it has been found necessary to ventilate the subways by means of fans placed at convenient points and communicating by special pipes with several manholes. A hand fan for temporary ventilation is shown in Figure 1, which also shows the iron cage used over the openings to prevent accidents.

Drawing in the Cables.—To enable the cables to be drawn into the ducts what is called *rodding* is resorted to, and consists in passing a flexible steel rod of about ¼-inch diameter through from one manhole to the next, or, which is considered a better plan, a set of wooden rods provided with joints so that they may be put together to form one long rod is threaded through.

When the next manhole is reached a rope is attached and drawn back by the aid of the rods, unjointing the latter as they come out.

The cable or cables, sometimes to the number of six, are then firmly and carefully attached to the rope and are drawn into the pipes by the men alone, or more often by the aid of a winch or windlass. All rough or sharp edges about the pipes must be carefully avoided to prevent damage.

(TO BE CONTINUED.)

ARTICLE III.

Electro-Plating with Zinc, Tin, Iron, Cobalt, etc.

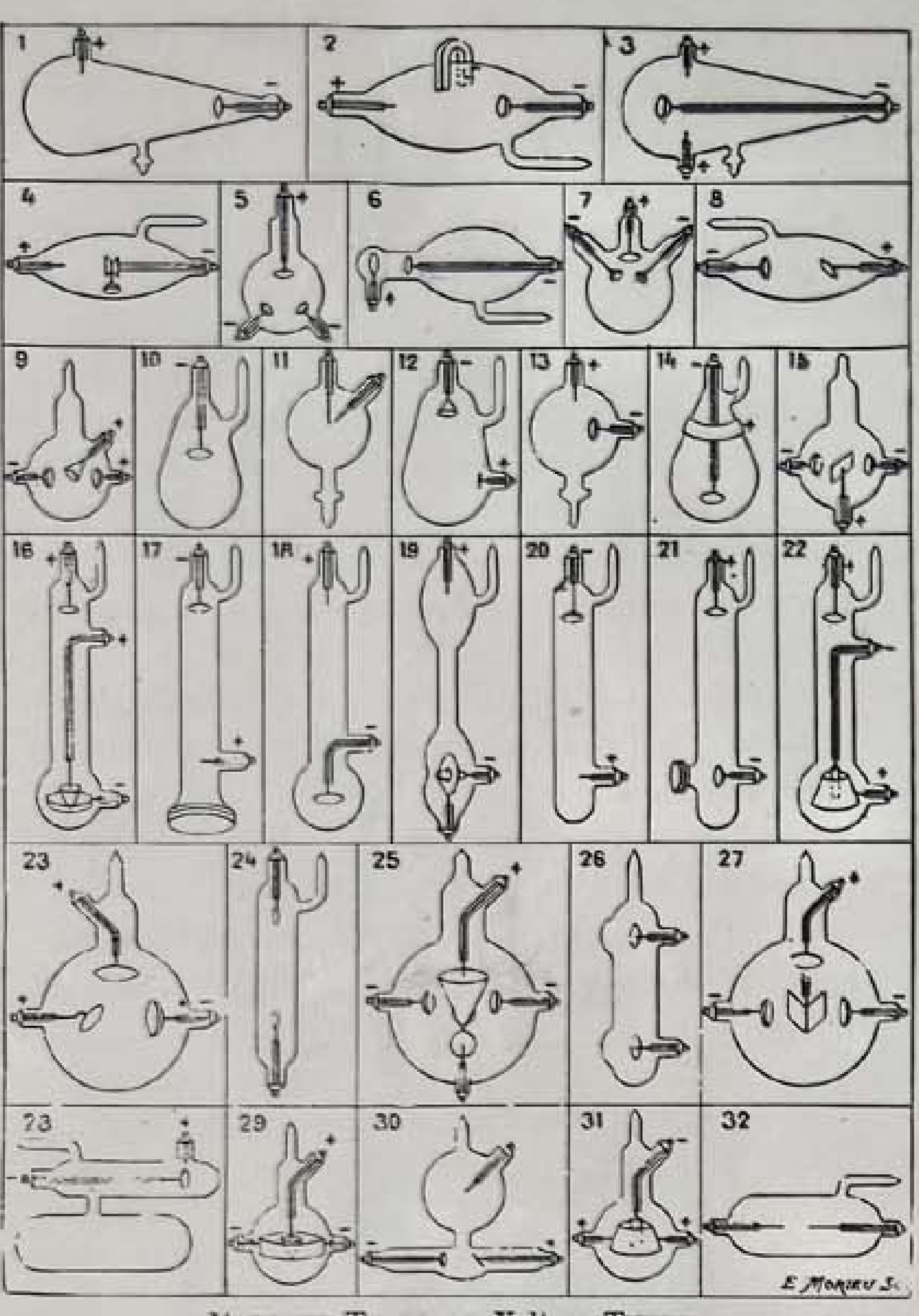
BY G. E. BONNEY.

Zinc has been electro-deposited from a solution of its sulphate by Mr. Gore whilst using a feeble current. It has also been deposited from its solutions of chloride, acetate, tartrate, ammonia sulphate and ammonia chloride. By M. Herrmann's process, a dilute solution of sulphate of zinc is mixed with a solution of an alkaline sulphate, such as that of ammonia, potassium, or sodium, and a strong current is employed. By Person and Lire's process, a solution is made up of one part oxide of zinc, dissolved in a solution of ten parts of alum in 100 parts of water. This is said to be easily decomposed with an E. M. F. of one volt, and to deposit its metal freely upon any other metal. But the electro-deposition of zinc has not received much attention from electro-metallurgists because of its own commercial value. Articles made of iron can be so much more cheaply and effectually coated with zinc by dipping them in a bath of the molten metal, as to entirely exclude all ideas of electro-depositing zinc for commercial purposes. As, however, the amateur plater or student may wish to try his hand at electro-zincing, I herewith give directions for making a solution which Mr. Watt has proved to give excellent results.

Dissolve 200 ounces of best cyanide of potassium in 20 gallons of water, and stir into this 80 ounces of strong liquid ammonia. Place several large clean porous cells in the solution, and fill these with the bath liquid. In each cell suspend a strip of copper, and connect each strip to the negative pole of a strong battery or a plating dynamo. From the other pole suspend a large anode of best milled zinc, and pass a current until 60 ounces of zinc have been dissolved from the anode. Next dissolve 80 ounces of carbonate of potash in part of the bath solution, stir this into the main bulk, and let it rest for 12 hours. Filter the bath before using, and work it with a current of from 4 to 5 volts, using anodes of best milled zinc. The articles for zincing should be cleaned and treated as for the deposition of silver, but not quicked in mercury.

The so-called tin vessels commonly in use for domestic and other purposes, are made of thin sheet iron coated with tin. The sheets of iron are dipped in a bath of molten tin, and thus acquire a thin film of this metal. The insides of copper and iron vessels employed for culinary purposes, are coated with tin by a similar process. Whenever it is deemed desirable to coat an article with tin, it may be cheaply and expeditiously done by this, the molten process. This being the case, very little attention has been given to the electro-deposition of tin, although this metal can be easily deposited from a large variety of solutions in excellent condition. Small brass articles, such a pins, hooks and eyes, and small copper articles, such as hooks and buttons, may be easily coated with tin by simple immersion in a bath composed of a saturated solution of cream of tarter, in which has been dissolved a small quantity of chloride of tin. The quantity of this salt is immaterial, as it is only employed to start the process, the remaining tin being supplied from anodes of sheet tin suspended in the bath. The liquid is kept at a boiling temperature, and the articles to be tinned are suspended in the bath between the tin anodes until sufficiently whitened, when they are rinsed in water and rattled about in hot bran until dry and bright. Iron articles may be similarly whitened in a boiling solution, made by dissolving 3 drams of fused protochloride of tin and 6 ounces of ammonia alum in 1¼ gallons of water. Bronze may be coated with tin in a hot solution of caustic soda in contact with anodes of pure tin.

(TO BE CONTINUED.)



VARIOUS TYPES OF X-RAY TUBES.

Some Various Types of X-Ray Tubes.

A large number of tubes have already been employed in different experiments with, and applications of, the X-rays for photography, and in connection with the fluoroscope.

Mr. G. Séguy has constructed and experimented upon several types, and he has gathered a collection which is illustrated in "La Nature."

There exist at the present time three methods of obtaining the X-rays. That employed in the very beginning is based on the direct action of the ray. The second permits of obtaining instantaneity in the radiograph, and is based on a reflection action. The third is a result of the combination of the first two methods.

In the accompanying engravings, Nos. 1, 2, 3, 4, 6, 7, 10, 11, 12, 13, 14, 17, 18, 20, 21, 24, 26, 28 and 32 are constructed according to the principles of the first methods. Nos. 5, 8, 9, 15, 16, 23, 25, 27, 29 and 30 employ the second method; that is, the theory of the reflection of the cathode rays and of the phenomenon of internal electrolysis of the volatilized molecules. The tubes Nos. 19, 22 and 31 produce X-rays according to the two combined theories.

The numbers accompanying each tube designate the design of the various experimenters, as follows: 1 and 2, Crookes; 3 Séguy; 4, Wood; 5, Séguy; 6, Chabaud-Hurmuzescu; 7, Séguy; 8, Thompson; 9, Séguy; 10, d'Arsonval; 11, Séguy; 12, Puluj; 13, Séguy; 14, d'Arsonval; 15, Le Roux; 16, 17 and 18, Sgèuy; 19, de Rufz; 20, Crookes; 21, 22, 23, Séguy; 24, Roentgen; 25, Brunet-Séguy; 26, 27, Le Roux; 28, Colardeau, 29; Séguy; 30, Colardeau; 31, Séguy; 32, Roentgen.

The Vitascope on Exhibition at Buffalo.

Mr. M. H. Marks is now giving a very fine exhibition of the vitascope at "The Edisonia and Vitascope Theatre" in Buffalo, N. Y. By the kindness of Mr. B. W. Hawkins, the electrician, we inspected the apparatus, and witnessed the exhibition. Some very interesting views are given, among which are the "Black Diamond Express" train running at the rate of seventy miles an hour, "The Fire Department" in full operation at a fire, "The Lone Fisherman," etc., etc. The X-Rays are also on exhibition. The admission is only ten cents, and we recommend that everybody in Buffalo go and see this interesting and instructive entertainment.

Some Interesting and Valuable Tables.

TABLE GIVING THE DIAMETERS OF WIRES OF VARIOUS MATERIALS WHICH WILL BE FUSED BY A CURRENT OF GIVEN STRENGTH.—*W. H. Preece, F.R.S.* $d = \left(\frac{C}{a}\right)^{2/3}$.

Current in amperes.	DIAMETER IN INCHES.								
	Copper. a = 10,244.	Aluminium a = 7585.	Platinum. a = 5172.	Ger. Silver. a = 5230.	Platinoid. a = 4750.	Iron. a = 3148.	Tin. a = 1642.	Tin-lead alloy a = 1318.	Lead. a = 1379.
1	0·0021	0·0026	0·0033	0·0033	0·0035	0·0047	0·0072	0·0053	0·0081
2	0·0034	0·0041	0·0053	0·0053	0·0056	0·0074	0·0113	0·0132	0·0128
3	0·0044	0·0054	0·0070	0·0069	0·0074	0·0097	0·0149	0·0173	0·0168
4	0·0053	0·0065	0·0084	0·0084	0·0089	0·0117	0·0181	0·0210	0·0203
5	0·0062	0·0076	0·0098	0·0097	0·0104	0·0136	0·0210	0·0243	0·0236
10	0·0098	0·0120	0·0155	0·0154	0·0164	0·0216	0·0334	0·0386	0·0375
15	0·0129	0·0158	0·0203	0·0202	0·0215	0·0283	0·0437	0·0506	0·0491
20	0·0156	0·0191	0·0246	0·0245	0·0261	0·0343	0·0529	0·0613	0·0595
25	0·0181	0·0222	0·0286	0·0284	0·0303	0·0398	0·0614	0·0711	0·0690
30	0·0205	0·0250	0·0323	0·0320	0·0342	0·0150	0·0694	0·0803	0·0779
35	0·0227	0·0277	0·0358	0·0356	0·0379	0·0498	0·0769	0·0890	0·0864
40	0·0248	0·0303	0·0391	0·0388	0·0414	0·0545	0·0840	0·0973	0·0944
45	0·0268	0·0328	0·0423	0·0420	0·0148	0·0589	0·0909	0·1052	0·1021
50	0·0288	0·0352	0·0454	0·0450	0·0480	0·0632	0·0975	0·1129	0·1095
60	0·0325	0·0397	0·0513	0·0509	0·0542	0·0714	0·1101	0·1275	0·1237
70	0·0360	0·0440	0·0568	0·0564	0·0601	0·0791	0·1220	0·1413	0·1371
80	0·0394	0·0481	0·0621	0·0616	0·0657	0·0864	0·1334	0·1544	0·1499
90	0·0426	0·0520	0·0672	0·0667	0·0711	0·0935	0·1443	0·1671	9·1621
100	0·0457	0·0558	0·0720	0·0715	0·0762	0·1003	0·1548	0·1792	0·1739
120	0·0516	0·0630	0·0814	0·0808	0·0861	0·1133	0·1748	0·2024	0·1964
140	0·0572	0·0698	0·0902	0·0895	0·0954	0·1255	0·1937	0·2243	0·2176
160	0·0625	0·0763	0·0986	0·0978	0·1043	0·1372	0·2118	0·2452	0·2379
180	0·0676	0·0826	0·1066	0·1058	0·1128	0·1484	0·2291	0·2652	0·2573
200	0·0725	0·0886	0·1144	0·1135	0·1210	0·1592	0·2457	0·2845	0·2760
225	0·0784	0·0958	0·1237	0·1228	0·1309	0·1722	0·2658	0·3077	0·2986
250	0·0841	0·1028	0·1327	0·1317	0·1404	0·1848	0·2851	0·3301	0·3203
275	0·0897	0·1095	0·1414	0·1404	0·1497	0·1969	0·3038	0·3518	0·3413
300	0·0950	0·1161	0·1498	0·1487	0·1586	0·2086	0·3220	0·3728	0·3617

FUSING EFFECTS OF ELECTRIC CURRENTS.

By W. H. Preece, F.R.S. See "Proc. Roy. Soc.," vol. xliv., March 15, 1888.

The Law—$C = a\,d^{3/2}$, where, C, current; *a*, constant; and *d*, diameter—is strictly followed; and the following are the final values of the constant, "*a*," for the different metals as determined by Mr. Preece:—

	Inches.	Centimetres.	Millimetres.		Inches.	Centimetres.	Millimetres.
Copper,	10,244	2,530	80·0	Iron,	3,148	777·4	24·6
Aluminium,	7,585	1,873	59·2	Tin,	1,642	405·5	12·8
Platinum,	5,172	1,277	40·4	Alloy (lead and tin 2 to 1),	1,318	325·5	10·3
German Silver,	5,230	1,292	40·8	Lead,	1,379	340·6	10·8
Platinoid,	4,750	1,173	37·1				

With these constants the two following tables have been calculated:—

TABLE SHOWING THE AMPERES REQUIRED TO FUSE WIRES OF VARIOUS SIZES AND MATERIALS.

No. S.W.G.	Diameter *d* Inches.	$d^{3/2}$	Copper. a = 10,244	Aluminium a = 7585.	Platinum. a = 5172.	Ger. Silver. a = 5230.	Platinoid. a = 4750.	Iron. a = 3148.	Tin. a = 1642.	Tin-lead alloy. a = 1318.	Lead. a = 1379.
14	0·080	0·022627	231·8	171·6	117·0	118·3	107·5	71·22	37·15	29·82	31·20
16	0·064	0·016191	165·8	122·8	83·73	84·68	76·90	50·96	26·58	21·34	22·32
18	0·048	0·010516	107·7	79·75	54·37	54·99	49·95	33·10	17·27	13·86	14·50
20	0·036	0·006831	69·97	51·18	35·33	35·72	32·44	21·50	11·22	9·002	9·419
22	0·028	0·004685	48·00	35·53	24·23	24·50	22·25	14·75	7·692	6·175	6·461
24	0·022	0·003263	33·43	24·75	16·88	17·06	15·50	10·27	5·357	4·300	4·499
26	0·018	0·002415	24·74	18·32	12·49	12·63	11·47	7·602	3·965	3·183	3·330
28	0·0148	0·001801	18·44	13·66	9·311	9·416	3·552	5·667	2·956	2·373	2·483
30	0·0124	0·001381	14·15	10·47	7·142	7·222	6·559	4·347	2·267	1·820	1·904
32	0·0108	0·001122	11·50	8·512	5·605	5·870	5·330	3·533	1·843	1·479	1·548

Note.—The size of "cut outs" or fuses for electric lighting circuits can be taken at once from the second table. Pure copper wire makes the best and most reliable cut out or fuse, and should never be less than 1 inch in length between the terminals to which it is fixed so as to prevent the cooling effect of the terminals.—A. J.

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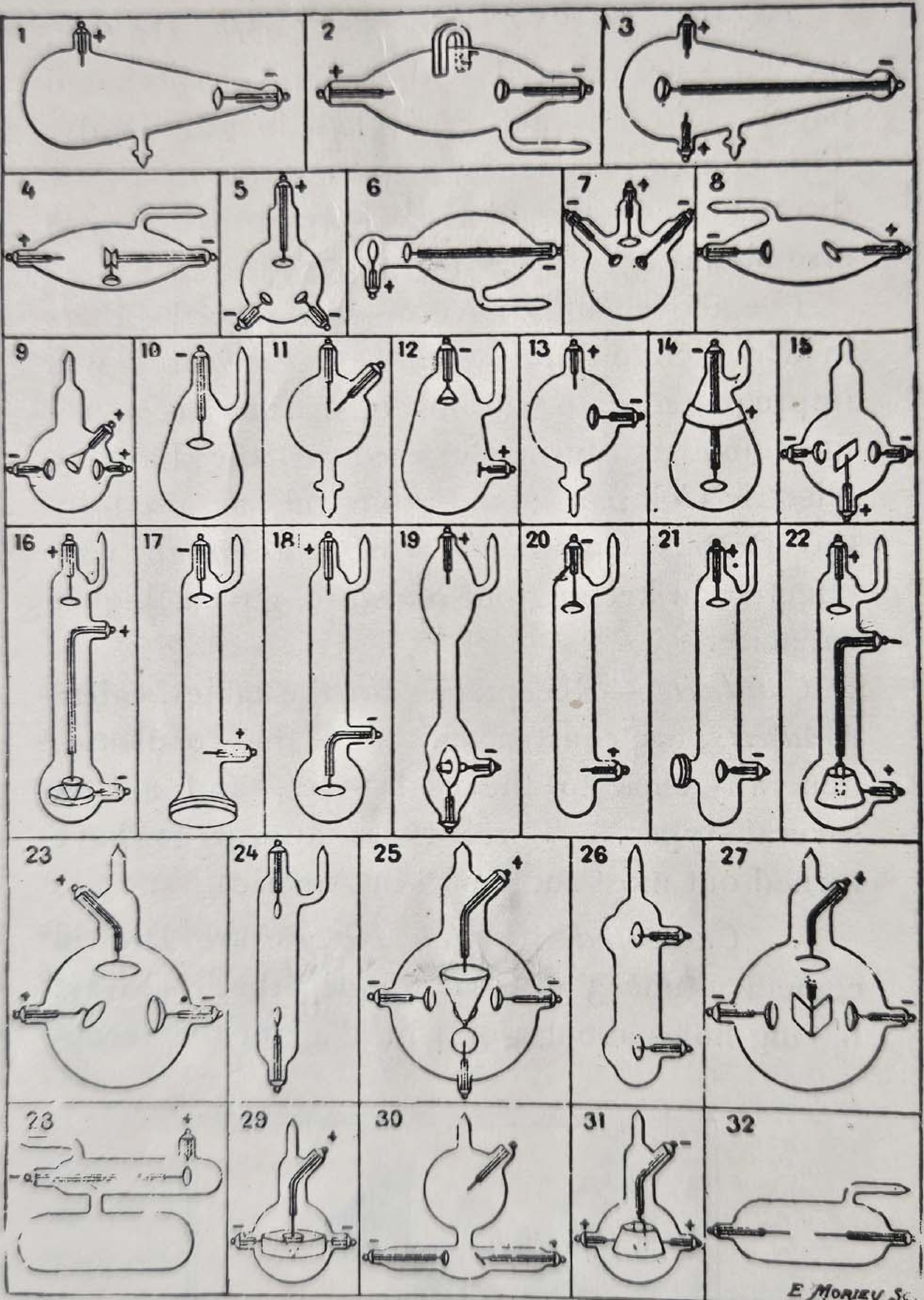
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E. MORIEU Sc.

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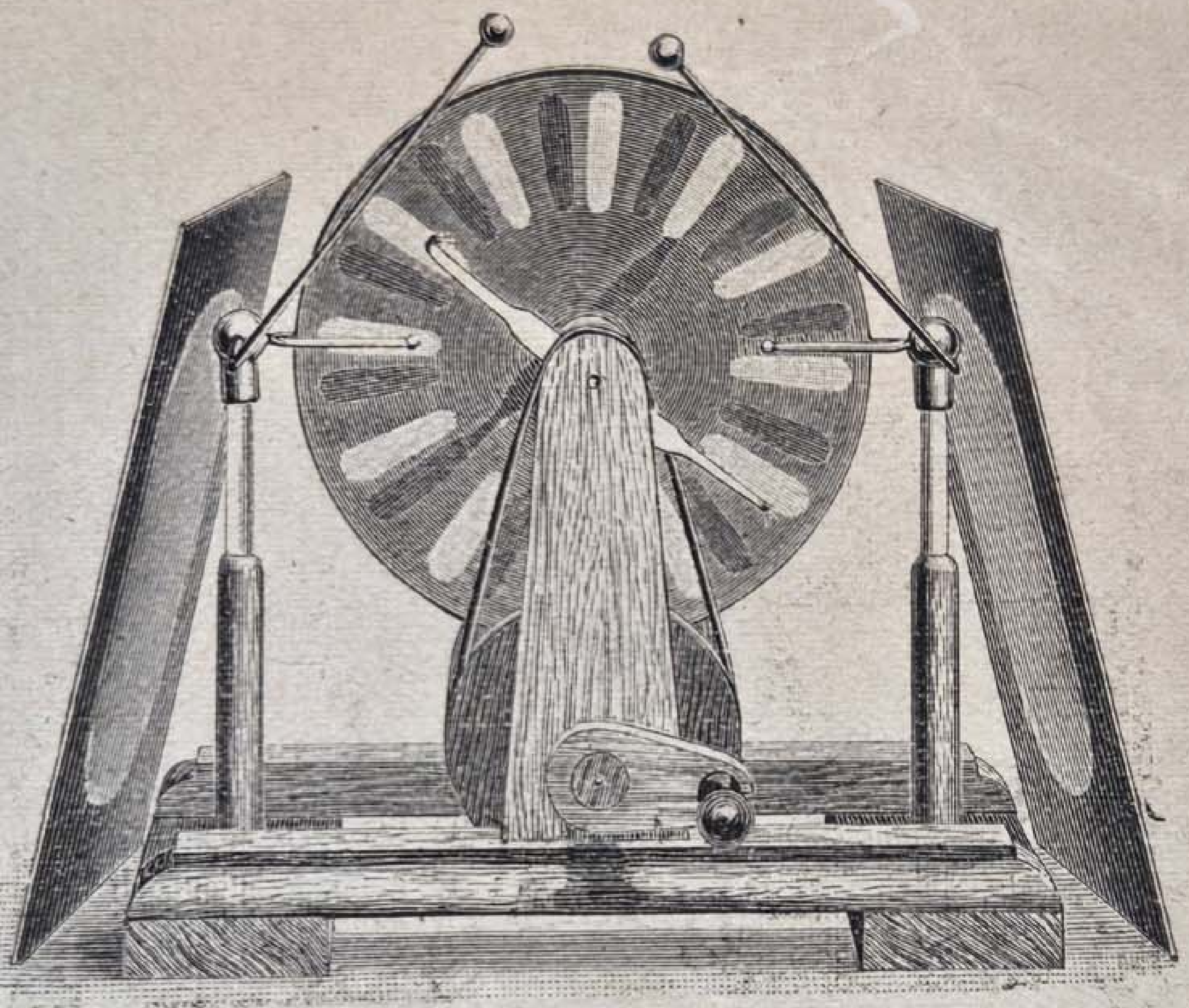

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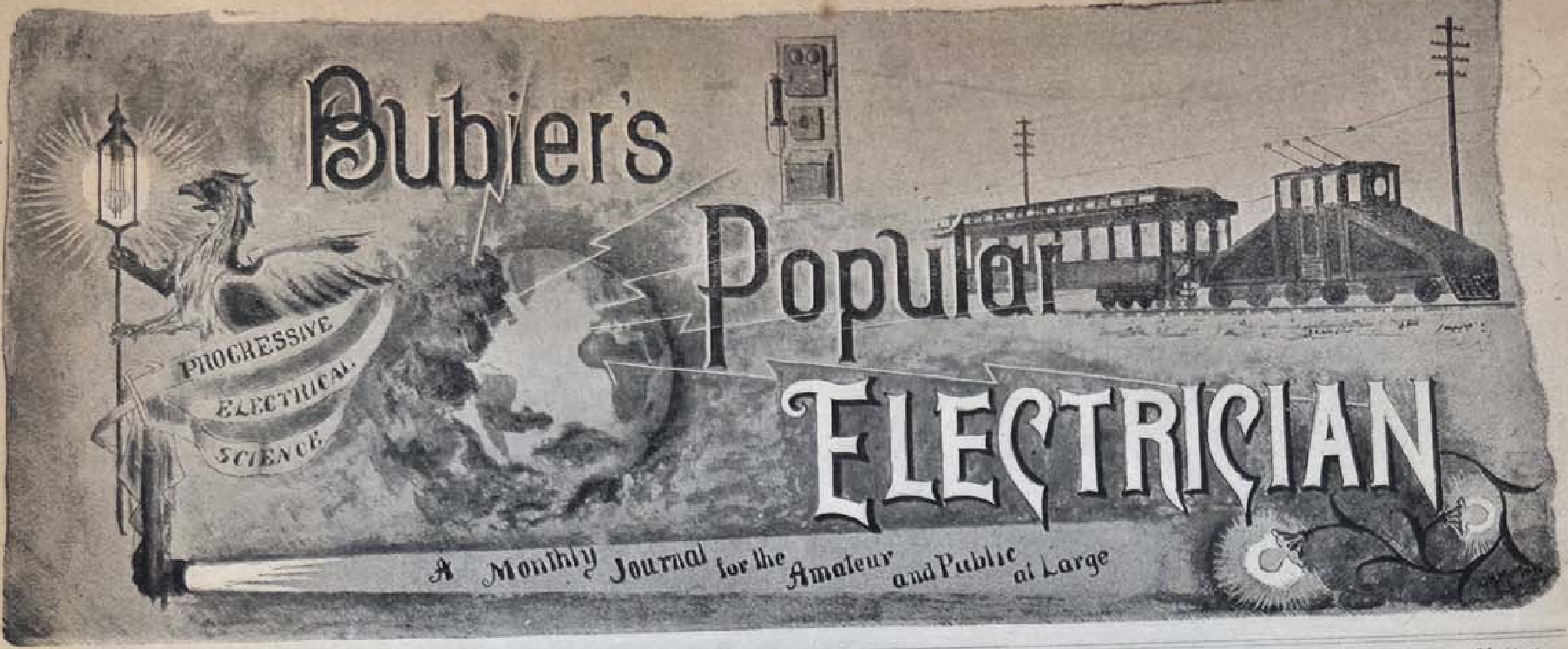

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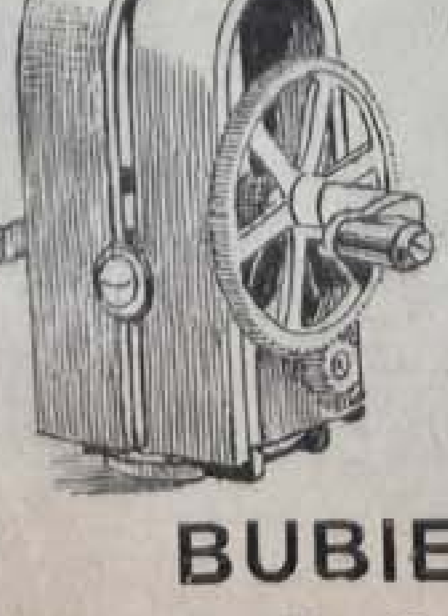

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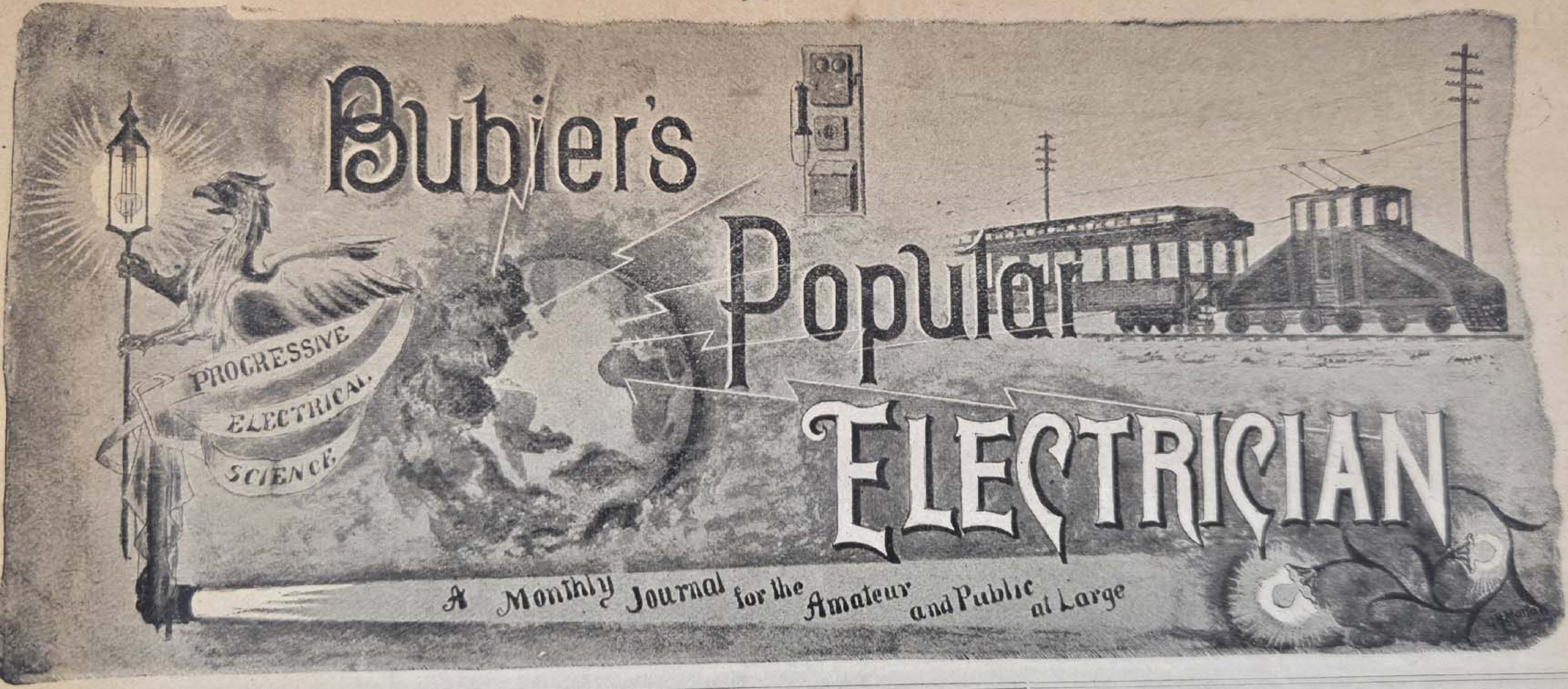
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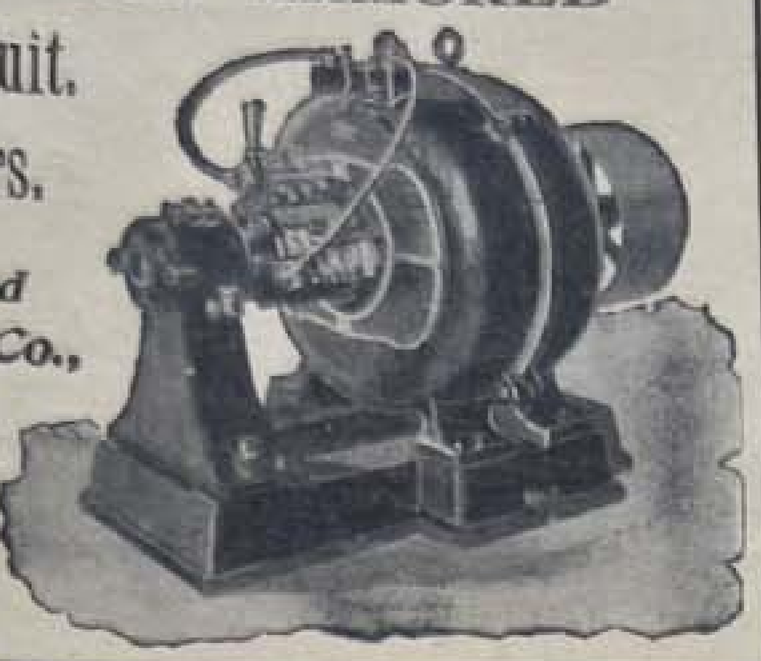

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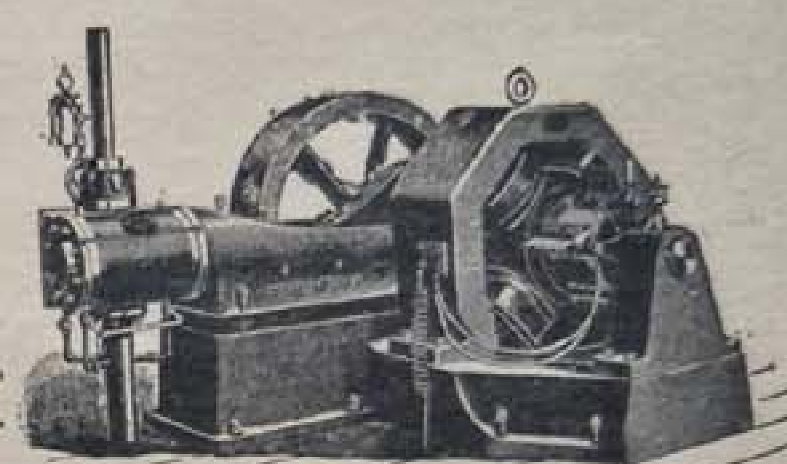

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ROENTGEN RAY EXPERIMENTS.

WHILE the interest, amounting almost to excitement, created among the general public by the discovery of Prof. Röntgen has almost subsided, such, we are glad to say, is not the case among scientists and inventors, who have at their disposal apparatus for carrying on experimental work of this nature. This is evident on glancing at the continuing contributions on the subject appearing in our columns. Indeed, the further study is pushed in this direction, the more it becomes certain that the Röntgen ray phenomenon will require the most careful investigation before its true character can be established. Already experiments seem to cast a doubt on the original belief as to the source of these rays, eminent experimenters, like Prof. Rowland and Prof. Elihu Thomson throwing the weight of their opinion in favor of the anode. Dr. Morton, with a very characteristic photograph, has shown that in his particular experiment the source of the X-rays was confined to a limited point of fluorescent material within the tube between the anode and cathode. It will be remembered that Prof. Röntgen, in his original essay, pointed out that the chief seat of the rays was located at the most brilliant phosphorescent spots on the walls of the tube, and was to that extent independent of either cathode or anode. For those who have not followed the history of the Röntgen ray we can strongly recommend the perusal of Mr. Osterberg's admirable résumé of the subject embodied in his lecture before the New York Electrical Society. We agree fully with Mr. Osterberg in recommending to all at work on, or about to undertake Röntgen ray experiments, to read carefully Prof. Röntgen's essay, which appeared in our issue of Feb. 12. As a collateral branch of investigation, much interest has been concentrated in fluorescent bodies, and investigators will, we ascertain, be grateful to Mr. Edison for having called attention to the tungstate of calcium, a material far more powerful than what had heretofore been commonly used.

In line with Röntgen ray experiments is the alleged discovery of a means for rendering transparent opaque objects placed in a certain position with regard to a number of chemical solutions. The description of this new development, as far as the inventor has permitted its publication, is given on another page. While, of course, we can not guarantee the authenticity of the story, we have given it on the testimony of reliable witnesses, and present it to our readers for what it is worth.

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FURTHER EXPERIMENTS IN FLUORESCENCE UNDER THE CATHODE RAY.

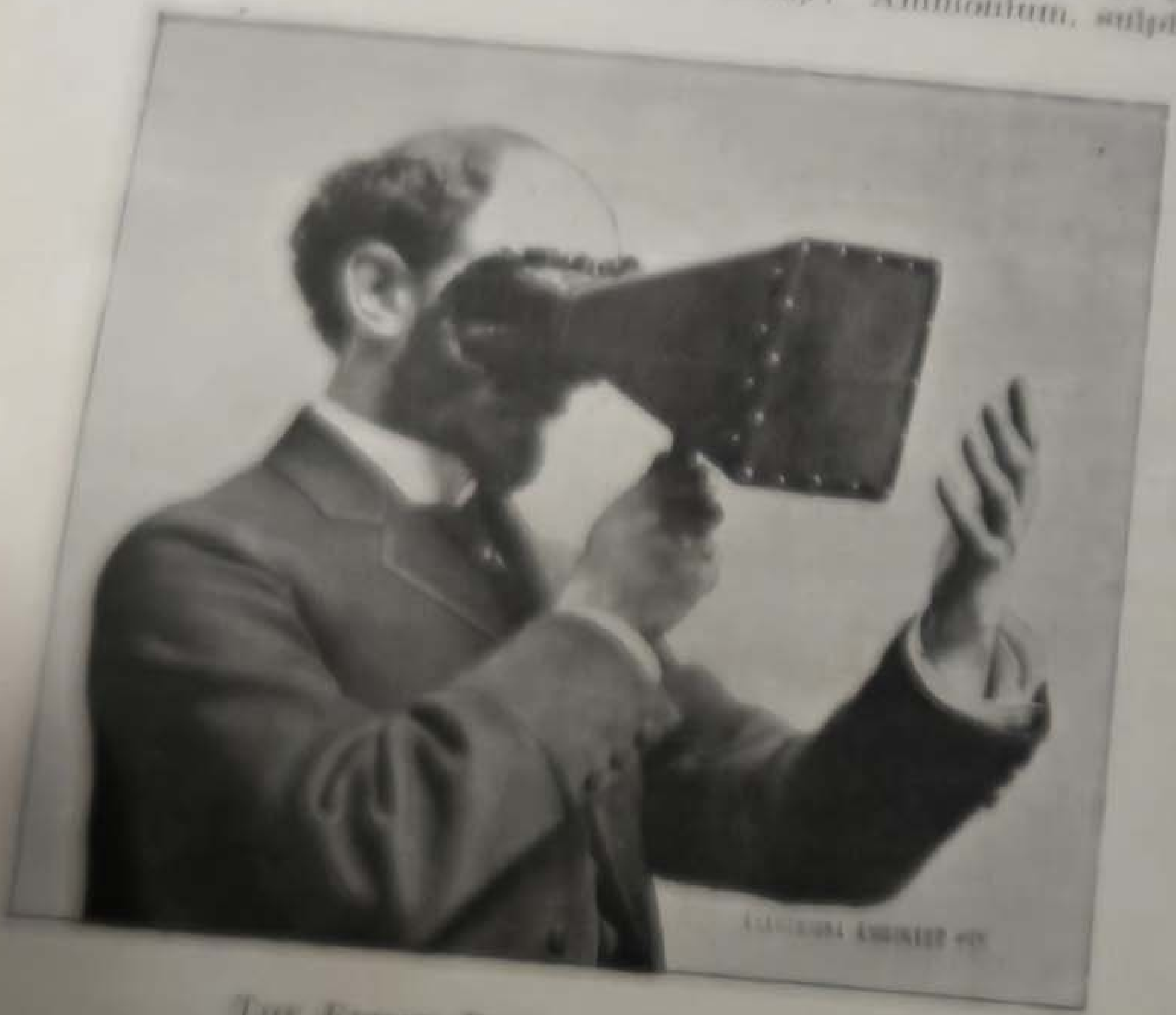
BY

Thomas A. Edison.

FURTHER experiments with the fluorescence of different chemicals under the influence of the X-ray have added a few more to the list already published. The following fluoresce: Calcium tungstate, tungstate of zinc, lithia benzoate, formate lead, carbonate lead, salicylate potassium, carbonate silver, sodium salicylate, sodium carbonate, sodium tungstate, zinc acetate, zinc chloride, zinc carbonate, molybdate zinc, benzoic acid, malic acid, diphenylamine, ruffigallic acid, pyridin nitrate.

I have so far found no salt in the following metals to fluoresce: Aluminum, antimony, arsenic, boron, beryllium, bismuth, cerium, chromium, cobalt, copper, gold, iridium, magnesium, manganese, nickel, tin, titanium.

The crystals of the following chemicals give spots of light when held close to the bulb within a dark box. The light has the glowworm color of phosphorescence, and is due to the electric discharge and not to the X-ray: Ammonium, sulpho-



THE EDISON FLUOROSCOPE IN USE.

cyanide, calcium formate, calcium nitrate, iron citrate, silver nitrate, soda, lime, zinc, cyanide, zinc hypermanganate, zinc valeriate.

With plates of fluorite I have found that the phosphorescence penetrates the plate very slowly. If held before a fluorescing tube for one minute, the phosphorescence penetrates for 1-16 of an inch deep in the plate. This part, when held edgewise, is brilliant; beyond is dark.

[The latest form of fluoroscope designed by Mr. Edison is that illustrated in the accompanying engraving. It consists of a flaring box, curved at one end to fit over the forehead and eyes, like a stereoscope. The end of the box is closed by a pasteboard cover, on the inside of which is spread a layer of tungstate of calcium, which material Mr. Edison reports he has found to possess six times the fluorescing power under the influence of the X-rays, as compared with barium platino-cyanide.

By placing the object to be observed, such as the hand, between the vacuum tube and the fluorescent screen, the shadow is formed on the latter and can be observed at leisure. In order to exclude all light from the screen, the curved part of the fluoroscope [illegible]

A NEW X-RAY "FOCUS" TUBE.

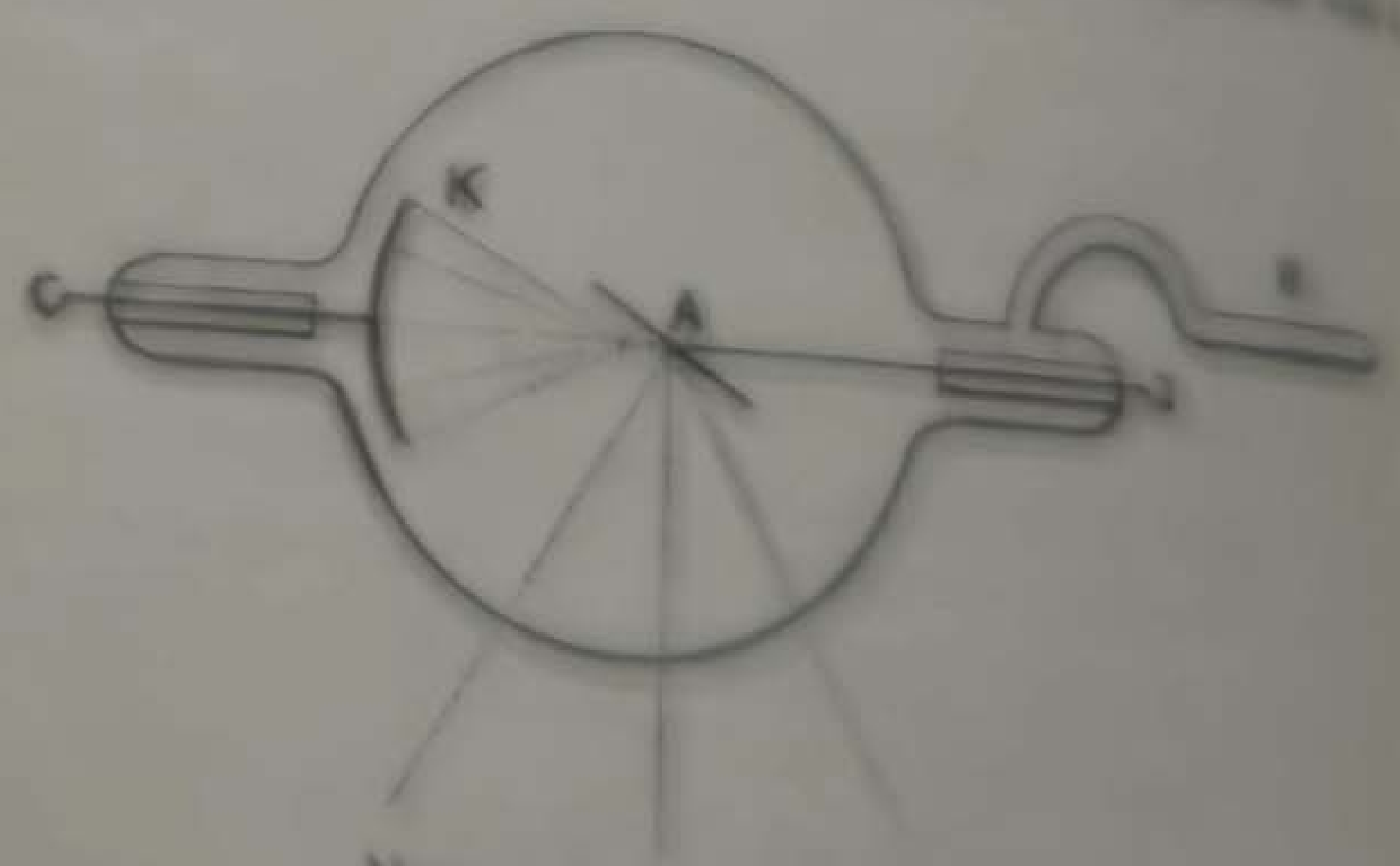
A NEW tube for producing the X-rays has been designed by one of the professors at King's College, London, which, according to the London "Electrician," is so great an improvement on anything that has been previously produced, that it will give a great impulse to the practical application [illegible] of the new photography.

The cathode rays are focused to a point upon a plate of platinum fixed on the anode. The X-rays [illegible] from this point, and, of course, produce [illegible] shadow of the object being photographed than from the extended luminous patch on the glass which has hitherto generally been used. [illegible] tion of the "Focus" tube. The cathode plate, K, is a disc of aluminum which focuses the cathode rays near the center of the bulb. The anode plate, A, is a piece of platinum foil placed at an angle [illegible] beyond the focus of the cathode rays. [illegible] cathode rays do not cross like rays of light [illegible] but behave rather like a number of fluid jets [illegible] focal point, and proceeding thence outwards as a [illegible] jet. The point where the rays impinge on the [illegible] retains its small dimensions, though the plate is [illegible] distance beyond the focal point.

Platinum is known to be one of the most opaque [illegible] for the cathode rays, and thus very little of the [illegible] passes through the platinum foil. The greatest [illegible] radiation is absorbed by the platinum, and gives [illegible] rays from the luminous point by a kind of diffuse [illegible] The anode plate, A, being set at an angle, the [illegible] radiation is directed downwards through the sides of [illegible] where it can be conveniently utilised to produce [illegible] graph in the usual way. The tube, H, through [illegible] bulb is exhausted, is shaped so as to permit [illegible] fixed in a stand at the required height. The [illegible] thode plates are connected to the terminals of the [illegible] coil by platinum wires fused through the glass.

ROENTGEN RAY LITERATURE.

THE "Comptes Rendus" for February 17 contains [illegible] numerous communications on the subject of [illegible] rays. M. R. Swyngedauw has a communication on the [illegible] of the lowering of the sparking distance. MM. L. [illegible] D. Hurmuzescu present a paper in which they state that they have verified that Röntgen rays are propagated in air [illegible] ing to the law of inverse squares. They also state that Röntgen rays are heterogeneous. They base this statement on the fact that they find the coefficient of transmission for [illegible] mm. thickness of aluminum to be about 0.85, and they go on to say that such a value is absolutely incompatible with the very sensible transparency that Professor Röntgen [illegible] for a plate of aluminum 15 mm. thick, if we assume [illegible] coefficient is independent of the Crookes tube employed [illegible] if it does not increase with the thickness traversed [illegible] say, if X-rays are not subjected when passing through [illegible] num to selective absorption, which is a proof of heterogen[illegible] If the value 0.85 were constant the total transparency [illegible]



NEW "X RAY" FOCUS TUBE.

sheet 15 mm. thick would be represented by 26 × 10^{-12}. MM. Benoist and Hurmuzescu then carried on experiments with increasing thicknesses. They found that the coefficient increased from 0.85 for sheets not exceeding 0.6 mm. thick, to 0.9 for sheets exceeding 1 mm. They next employed different Crookes tubes under identical conditions, and found that the coefficient of transmission varied from 0.85 to 0.78. Another communication was made by MM. Auguste and Louis Lumière describing some experiments carried out by them with a view of ascertaining the amount of absorption which Röntgen rays undergo when passing through sensitive films. After ten minutes' exposure they found that photographic effects were produced through a packet of 250 sheets of gelatino-bromide-silver paper; they further found that 300 sheets of paper without the bromide emulsion exercised the same absorptive effect as 150 sheets of sensitized paper. They then experimented with photographic plates having different degrees of sensitiveness for white light in the ratio of extent of 1.8 to 30, and they found that within the limits of their experiments this ratio was exactly the same for Röntgen rays.

OPAQUE OBJECTS MADE TRANSPARENT BY RAYS PASSING THROUGH CHEMICAL SOLUTIONS.

WE have received from a correspondent at Parkersburg, W. Va., an account of an alleged remarkable discovery which, if verified, places it well on a par with the now famous discovery of Professor Röntgen. The discovery referred to is due to Mr. A. G. Davis, of Parkersburg, and consists in an arrangement of chemical solutions, the effect of which is to make opaque bodies transparent to light.

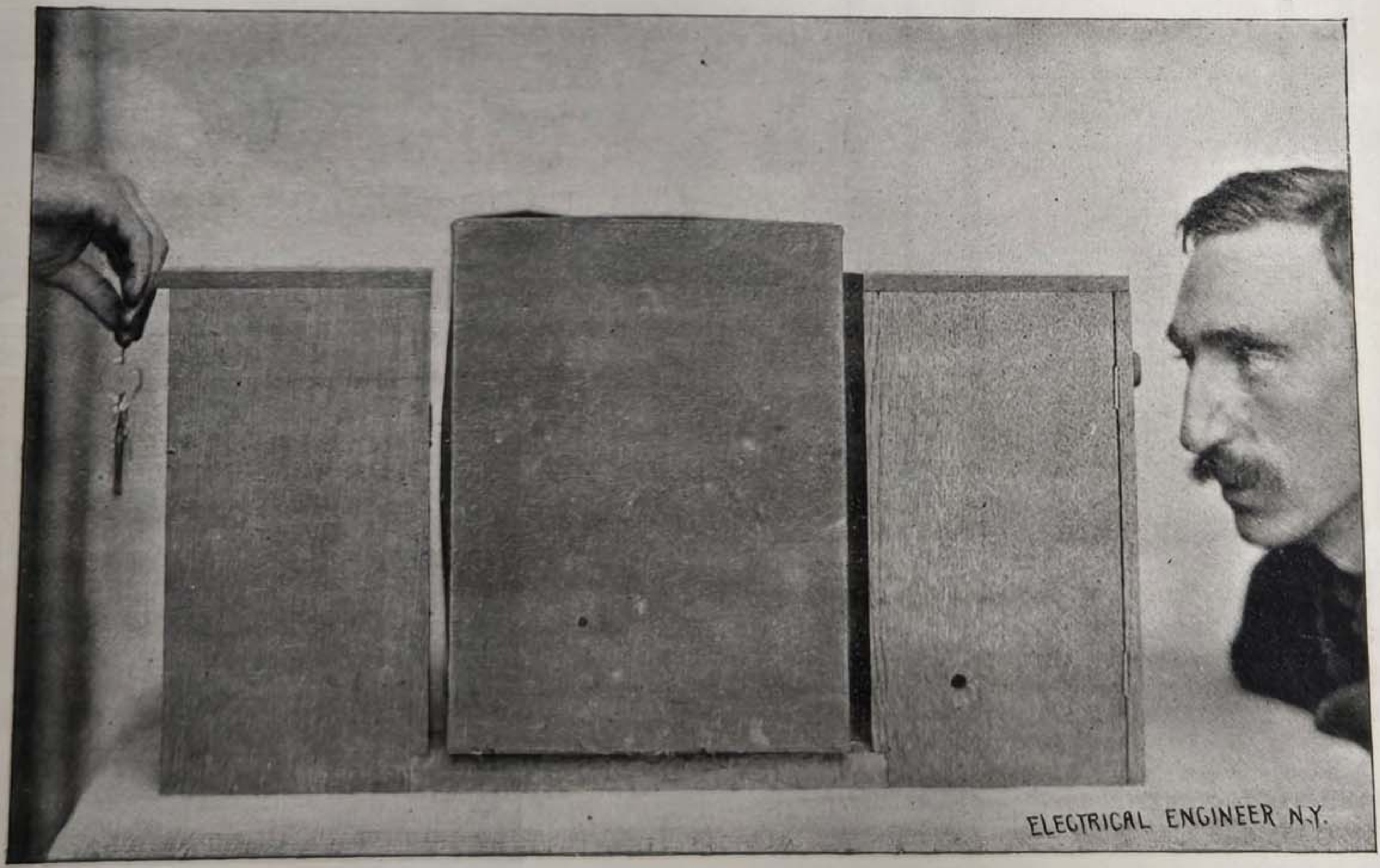

ELECTRICAL ENGINEER N.Y.

FIG. 1. DAVIS'S METHOD OF VIEWING OBJECTS THROUGH OPAQUE BODIES, BY THE AID OF CHEMICAL SOLUTIONS.
Photograph by Emil Korb, of Parkersburg, W. Va.

The discovery is said to have come about in this way: Mr. Davis, who is a jeweler by trade, was engaged in soldering, seated at a table with three bottles of chemicals before him. In one hand he held a fourth bottle and in the other a file. By accident, he held the file between the bottle in his hand and the three bottles on the table, and, much to his surprise, only the ends of the file were visible. A number of other objects, including the hand, were tried, all appearing transparent. The accompanying engraving, Fig. 1, shows the first apparatus constructed by Mr. Davis, consisting of two end boxes containing the bottles of chemical solutions, with what is said to be a solid block of steel 12 x 18 x 25 inches between them. The internal arrangement of the end boxes is shown in Fig. 2, which exhibits their contents exposed. Both these boxes in their latest form have glass fronts and backs. The box on the left hand is the one containing the single chemical and which is the one placed next to the observer. The bottle has two wires connected to it which extend to a metal plate inside of the small box shown above the bottle. A crank is so arranged that by turning it the contents of the bottle are shaken, and this agitation is said to produce the effect of making the metal plate inside the small box transparent.

The box farthest from the observer is shown at the right in Fig. 2. This also contains a small auxiliary box, tightly closed, with a one-inch aperture and piece of tinfoil back of it and a piece of windowglass over it. This small auxiliary box also contains a metal placed behind the aperture, and from the plate wires extend to the bottles shown. In order to avoid the suspicion that the results may be due to an arrangement of concealed mirrors, placed in the board supporting the two boxes and block of steel, in the latest arrangement the two boxes are entirely independent of each other. In a communication received from Mr. Davis himself, that gentleman writes: "I have found by a combination of four chemicals that I can make transparent any opaque object, one being on one side of the opaque object and the other three on the other side. I have further made a second and later discovery, that the powers of the chemicals can be transmitted by means of small wires to a metal plate, which, if enclosed in a dark box, makes a sort of fluorescent screen, and by looking through it all opaque objects become transparent the same as if looking through the one bottle of chemicals.

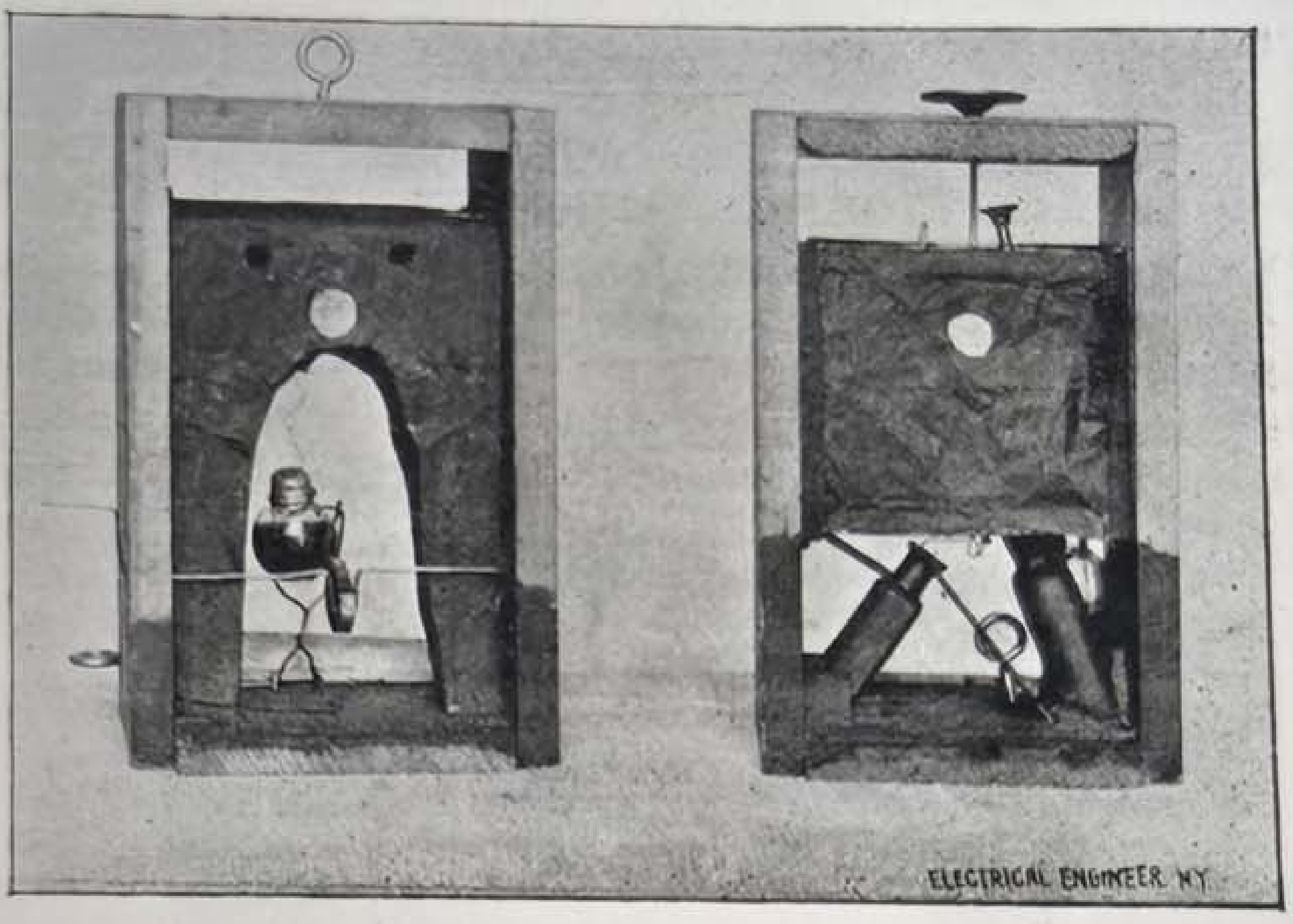


FIG. 2. THE BOXES EXPOSED.

"I will not reveal the name or nature of the chemicals, nor

THE
Electrical Engineer.

Vol. XXI. APRIL 8, 1896. No. 414.

ELECTRIC LIGHTING.

ARE ROENTGEN RAY PHENOMENA DUE TO SOUND WAVES?

BY

Thomas A. Edison.

FURTHER experiments with the Röntgen ray have developed some new phenomena which may aid in explaining the mode of transmission. In studying various photographs taken in the past month there were certain features which were difficult of explanation except on the theory that the X-ray was a sound wave of very small wave length, and that the shadows were sound shadows, the peculiarities of which are known, one of the best illustrations being the experiments of Le Conte in the Bay of San Francisco, published in the "Philosophical Magazine," February, 1882.

The experiment was briefly this: Le Conte placed a bottle under water on one side of a pile; at a distance of 200 feet from the pile he exploded a charge of nitro-glycerine, also under water. The concussion wave shattered the bottle. He then placed it behind the pile and exploded a charge. The bottle was uninjured. In another experiment he placed a glass tube at right angles to the pile, its ends projecting a couple of feet on each side. The portions within the shadow were uninjured, the ends were broken off. I therefore conducted a number of experiments with this theory in mind.

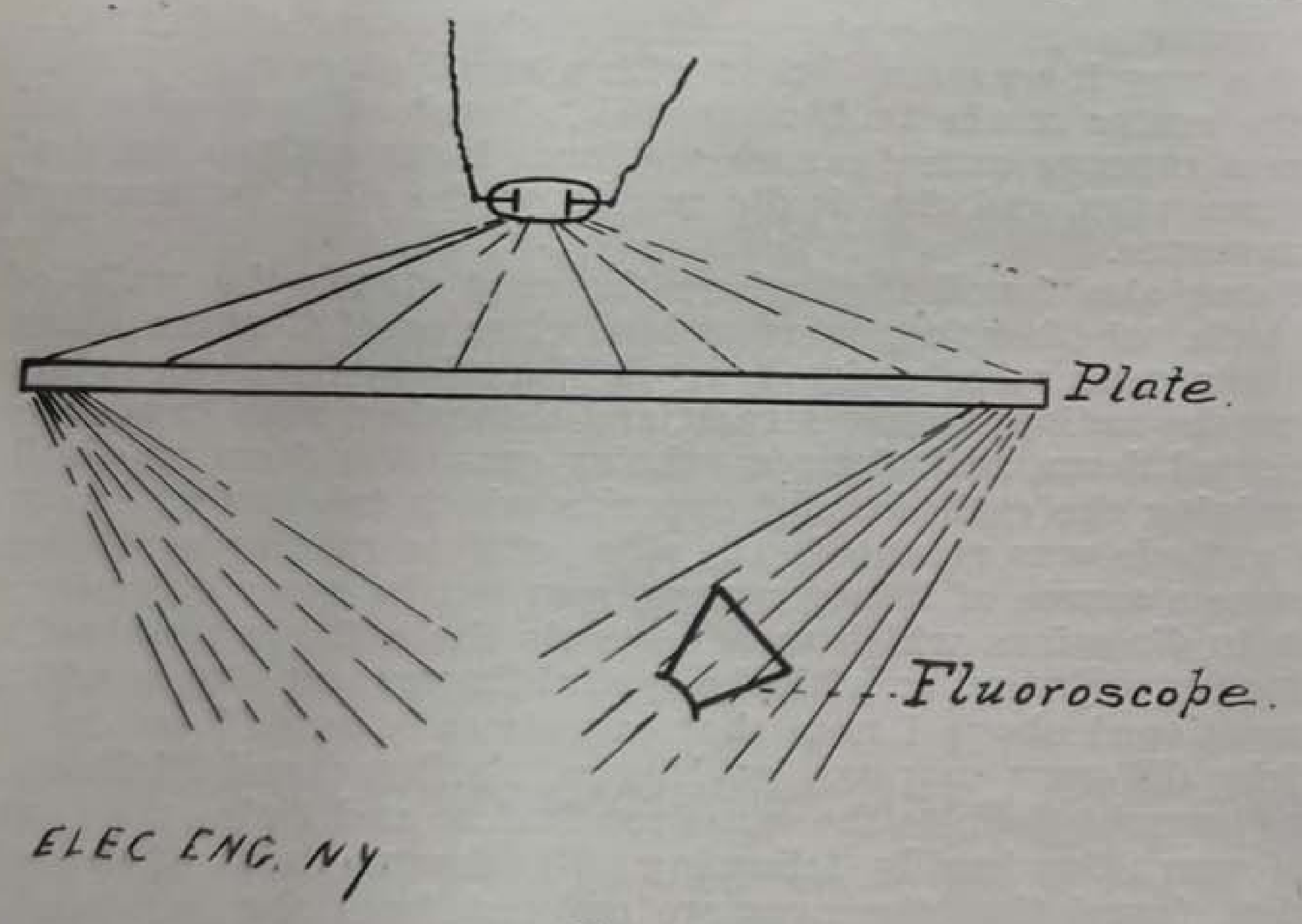


FIG. 1.

The fluorescent bulb was placed on one side of a steel plate, Fig. 1, the observer being on the opposite side. When the fluoroscope was placed against the steel plate directly opposite the bulb on the other side, no light was observed; but when the fluoroscope was made to approach within six inches of the edge and well within the shadows it lighted up. The direction of the X-ray was found by a moving bar of iron, so as to obtain the sharpest image. Fig. 1 illustrates the direction of the ray as near as possible with the rough apparatus used.

The second fact which possibly tends to confirm the sound wave theory is that liquids do not fluoresce with the ray, at least none that I have tried. Crystals alone fluoresce, except in one or two cases, such as precipitates, and these may not be amorphous. The crystal is resonant to the wave.

The third observation is that a tube with a vacuum so low as to give striae and from which ordinarily no X-ray can be obtained, no matter how long a dry plate is exposed to it, can be made to give the ray by a powerful blast of air on the spark of the break wheel of the primary and a spark gap in the secondary, the wires of which are guarded up to the very end.

Another observation is that the sharpness of the shadow depends on the abruptness of the break. A very weak bulb may be made to give sharper shadows than one giving twice the luminosity in the fluoroscope, which has a connection with this theory. Another fact is, that when tubes are on the pump continuously the vacuum will depend upon the pump, that is, the amount of mercury running per minute. The vacuum will reach a certain stage and keep that way for several days, the pump being able to reach a certain exhaustion, and no further, the air brought in by the mercury being the limiting point.

With Sprengel pumps used for incandescent lamp exhaustion the stage of vacuum reached is rather too high for the best X-ray, but still very good. But if a device is used whereby a definite amount of air is permitted to enter the bulb the X-ray will flash out with great brilliancy in the fluoroscope, lasting for 10 or 15 seconds until the pump has exhausted it to the limiting point mentioned. With this device a moving object can be seen through 30 inches of pine board. By means of the fluoroscope the bones of the arm and shoulder are of extraordinary sharpness.

[For the benefit of our readers we print below the article above referred to by Mr. Edison.—Eds. E. E.]

EXPERIMENTS ON SOUND SHADOWS.

"Experiments with Stout Glass (soda water) Bottles."—In these experiments the observer stood on the top of a vertical cylindrical pile (the trunk of an Oregon pine) about one foot in diameter, situated about forty feet horizontally from the explosive cartridge. The bottle, being secured to a rigid rod, was first plunged under the water from ten to twelve inches behind the pile (Fig. 1, A), that is, within its geometrical shadow. The shock of the explosion did not injure the bottle. It was then plunged into the water in front of the pile (Fig. 2, B), or outside its geometrical shadow. In this position the bottle was shivered to atoms by the concussion due to the explosion. As viewed from the experimenter's situation on the top of the pile, Fig. 1, A′ and B′, indicate the two positions of the bottle in the preceding experiments.

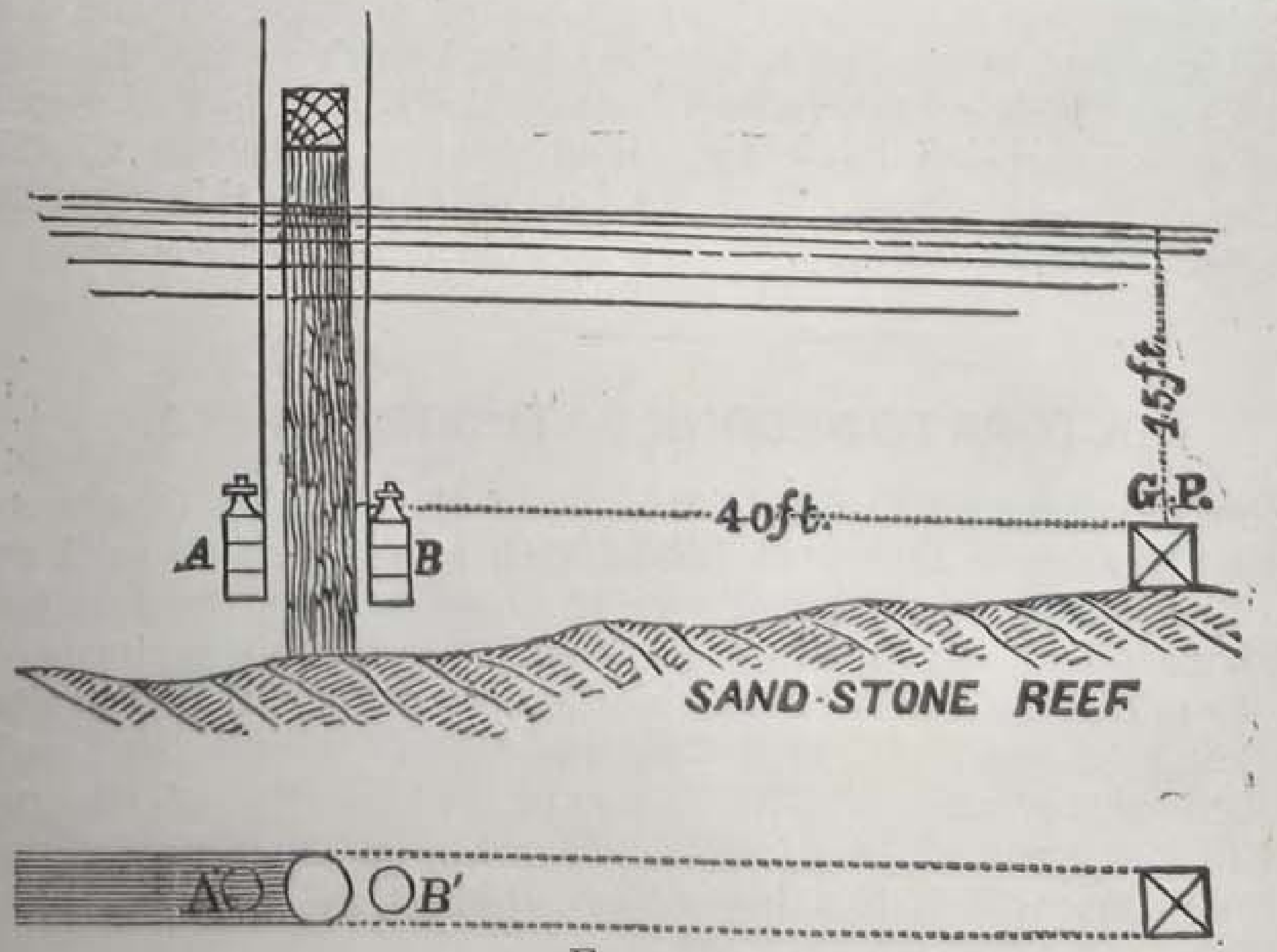


FIG. 2.

The experiments were varied by plunging bottles into the water in various positions around the pile, within and outside of its geometrical projection from the explosive center; and in all cases they were protected from injury when within the geometrical shadow, and were shivered when outside of the same. The same results took place whether the bottles were filled with water or with air.

The breaking of a glass by a sudden shock communicated by means of water is a fact long known, and is illustrated by the old familiar class experiment of exploding a "Prince Rupert drop," while its bulb is plunged into an ordinary apothecary's phial filled with water.

"Experiments with Stout Glass Tubes."—The cylindrical glass tubes employed were about six feet long and 1.5 inches in diameter, the glass being about 0.5 of an inch in thickness. They were covered by pasting cartridge paper over them, so as to prevent the loss of fragments when breakage occurred.

The tubes were adjusted to a framework of wood so arranged that they could be plunged in a horizontal position beneath the surface of the water behind the pile, the axis of the tube being at right angles to the plane of its shadow, and held there (the observer standing as before on the top) with the middle of the tube in the geometrical shadow, while the two extremities projected on either side about 2.5 feet beyond the boundaries of said shadow (Fig. 3, C and C'). In every case the shock of the explosion shivered the projecting portions of the tube, and left the portion within the shadow uninjured. The boundaries between the broken and the protected portions of the glass were sharply defined.

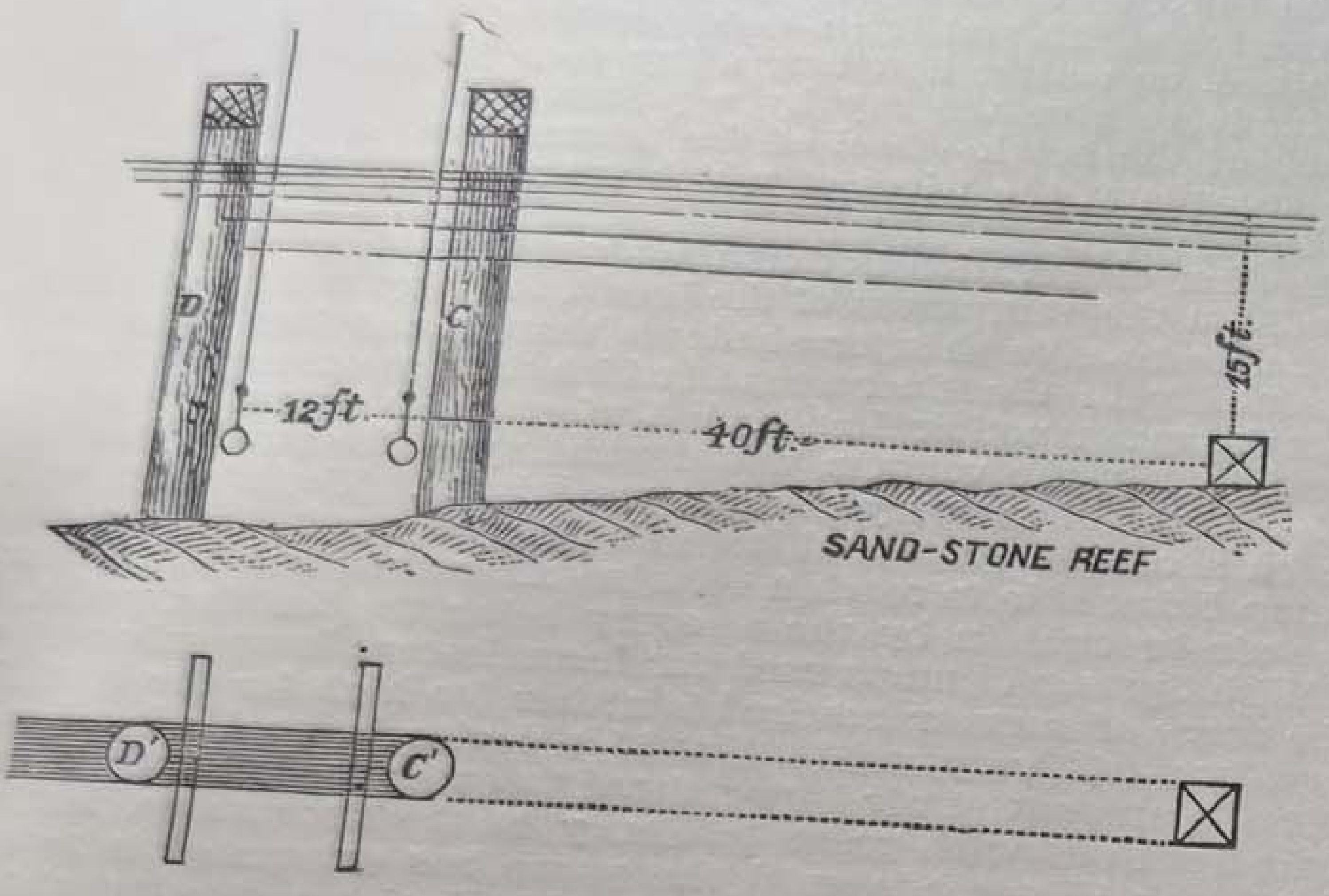


FIG. 3.

By standing on the top of a second pile, in the direction of the axis of the shadow of the first pile, and distant about 12 feet, the experiments were varied by plunging the framework and tubes—adjusted at right angles to the plane of the prolonged shadow—into the water at this distance (12 feet) from the obstacle which obstructed the sound wave transmitted by the liquid (Fig. 3, D and D'). The shock of the explosion produced sensibly the same results as when the tube was near to the obstructing obstacle. The protected portion of the horizontal glass tube was sensibly equal in length to the diameter of the pile casting the shadow; hence the shadow of the cylindrical pile extended back for about 12 feet between sensibly parallel vertical planes, and its boundaries, at this distance, were still sharply defined.

DOCTORS TO BECOME CATHOGRAPHERS.

Cathodography will shortly be one of the regular features of the Post-Graduate Hospital, Twentieth street and Second avenue. The utility of taking X-ray pictures in surgery has been demonstrated so often that the hospital authorities have decided to set aside one of the smaller wards for that purpose; and they will equip it with Crookes tubes, Rhumkorff coils, sensitized plates and all the other paraphernalia of the new art. For the generation of electricity they will employ a powerful machine, which has heretofore done service as an ozone generator.

GIFT OF A PLANT TO BLAIRSTOWN, PA.

John I. Blair, a millionaire, has just completed an electric plant at Blairstown, Pa., and presented it to Blair Hall. The plant cost $15,000. The current was turned on for the first time a few days ago, 67 lamps being used to light the town.

THE ROENTGEN RAY SOURCE.

BY

Elihu Thomson

SINCE writing my brief statement, in which it was set out that the anode was possibly the source of the Röntgen rays within the Crookes tube, and not the cathode, I have continued my experiments and investigations and have come to the conclusion that I was mistaken, largely owing to the particular structure of the tubes tested. Indeed, my later experiments have led me to this conclusion, which I think will require no amendment, namely, that the Röntgen rays are produced by the bombardment of any surface within the Crookes tube by cathode rays, or the radiant matter of Crookes; that fluorescence has nothing whatever to do with it, since substances which are bombarded and which do not fluoresce give out the rays—notably a piece of platinum. Lead glass, which fluoresces less than German glass, is still a strong source of the Röntgen rays when bombarded by the cathode rays. I have also been led to the conclusion that the more fluorescence there is produced by the bombardment the less energy will be available for Röntgen rays.

Another result of my observations has been to determine the fact that the Röntgen rays are emitted in all directions from the bombarded surface, and are not special to any particular direction. They are even emitted backward towards the cathode from which the rays which bombard the surface are sent.

In my experiments I find a very convenient way to determine the direction of the rays to be a modification of the fluorescent screen. In this tube a small patch of fluorescent material is mounted at some point between the two ends of the tube itself and backed by dark paper as usual. An opening for the eye is provided at one end of the tube and a moderate size opening at the far end, or the one nearest to the Crookes tube, while the whole screen tube is made of metal to prevent any lateral entrance of Röntgen rays. It will be evident that in this case, when the eye and the fluorescent patch and the distant opening are in line with the source or point of emission of the rays in the Crookes tube, fluorescence will be obtained, but at no other position. Hence, when the tube is so pointed or adjusted that fluorescence is seen it is only necessary to follow back the direction of the tube to lead to the source of the rays. By changing the direction in which observations are made, it is very easily seen that all of the directions determined will converge at some place which is the source of the rays. In this way it was found that with a small piece of platinum in the center of the bulb upon which bombardment occurred from a concave cathode, such platinum became the source of Röntgen rays, and that it did not show the slightest trace of fluorescence.

It was also found that where the rays struck the walls of the bulb, whether they were of lead glass or of German glass, Röntgen rays were emitted in all directions from the place where the radiant matter struck, and that when such rays were projected down and along a tubular extension from the bulb containing the cathode, and opposite which tubular extension the cathode was mounted, the sides of this tubular extension became a source of Röntgen rays, sent out in many directions, even in directions which were towards the cathode terminal.

Since experimenting with the special fluorescent screen which is mentioned above I note that experiments carried out in an entirly different manner by Messrs. Scribner and McBerty have brought them to the same conclusion, and I also note that Professor Stine has, by following still other methods of investigation, found that the rays are emitted from the bombarded surface. It is interesting, further, to find that, according to an account appearing in "The Electrical Engineer," page 340, an improved tube designed by one of the Professors of King's College, London, has a piece of platinum, which is made the anode for convenience, and which platinum becomes, when bombarded by the cathode rays, the focalized source of Röntgen rays within the tube. I may say that one of the best tubes in my possession, and one which gave the sharpest image, had a piece of platinum foil mounted in the focus of the cathode rays, which platinum foil had become sagged or bent at an angle, its structure resembling the last mentioned tube designed in London except that it had a separate anode.

HOLYOKE, MASS.—The Connecticut River Manufacturing Co., Holyoke, Mass., have purchased a 40-h. p. Ball engine for electric lighting from J. H. Houghton, Boston representative of the Ball Engine Company, Erie, Pa.

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[1] See page 358. [2] See page 357.

I. CENTRALIZING X-RAY BULB.
II. EXTERNAL ELECTRODES VACUUM BULB.

BY WILLIAM JAMES MORTON, M. D.

I.

IN a communication to the March 25th issue of this journal I described an experiment which seemed to demonstrate that the X-ray proceeded from a piece of fluorescent material mounted within the bulb, independent of its walls, and mentioned that I had had constructed and was using a Crookes tube so modified as to embody this idea. The main purpose of the independently mounted fluorescent substance was, as then stated, to receive upon its surface the focused cathodic stream at such an angle that the X-rays might be projected out of the tube in a directive manner. Incidentally I proposed the query, based upon the experiment referred to, as to whether the X-ray might not proceed from the fluorescence only. In this issue I take pleasure in submitting a photographic illustration, Fig. 1, of the centralized X-ray bulb then referred to and described.

The cathode is shown at C, Fig. 2; the anode at A; F, is a piece of fluorescing substance.

The fluorescent material is placed at an angle to the cathodic stream and in such a position as to most conveniently permit of radiation proceeding outward through the sides of the bulb.

I have also had constructed a bulb resembling this one, with the exception that both electrodes focus upon the fluorescent substance.

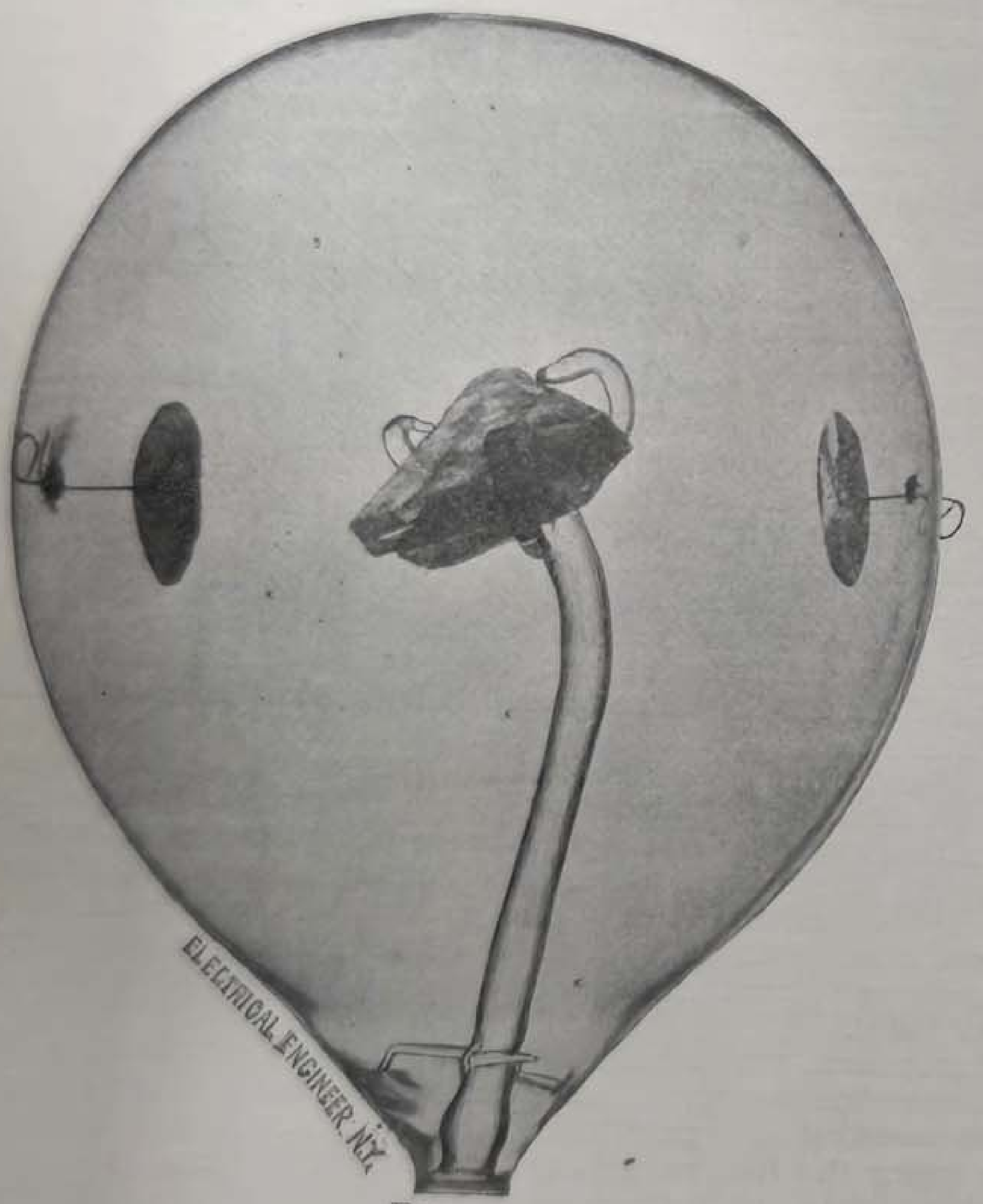


FIG. 1.

The bulb illustrated was made for me by Messrs. Eimer and Amend. Any one of a great variety of fluorescent substances may be thus mounted and acted upon.

II.

Unable, like most others interested in making Röntgen pictures, when the announcement of their possibility was first made, to obtain Crookes' tubes, I was forced to turn to other devices of vacuum bulbs.

Omitting details of many experiments, I would like to record, for the benefit of those who wish to work upon this subject, a final form of vacuum bulb which I have arrived at which seems to embody a practical principle of construction, namely, that in a vacuum bulb provided only with external electrodes, the cathodic stream is projected opposite to and against the anodal electrode and its line of projection passes through the anode to reach the sensitized plate.

With this bulb—and it is the only one I, for a long time, used—I made shadowgraphs of the hands, feet, wrist and elbow. It was used with an eight-plate (discs thirty-two inches in diameter) static machine, connected in the circuit existing between the external armatures of Leyden jars, and without a converter of any sort. I found it preferable to use small Leyden jars. But it may also be employed in connection with the induction coil or coil and converter.

The bulb was blown and the vacuum made by Messrs. Eimer and Amend. Reference to the following illustration will enable any amateur to make one: The bulb is about 7½ inches long by 4½ wide. Fig. 3 shows its appearance before the electrodes are fitted to it. Fig. 4 requires a brief explanation. The cathode, C, is a disc of thin sheet aluminum about the thickness of ordinary tinfoil annealed and affixed and fitted directly upon the glass with mucilage; its diameter is 3½ inches. Beneath its outer edge is a thick coating and ring of shellac, S, for the purpose of raising the periphery of the cathode disc up and away from the glass, and thus to prevent a possible perforation.

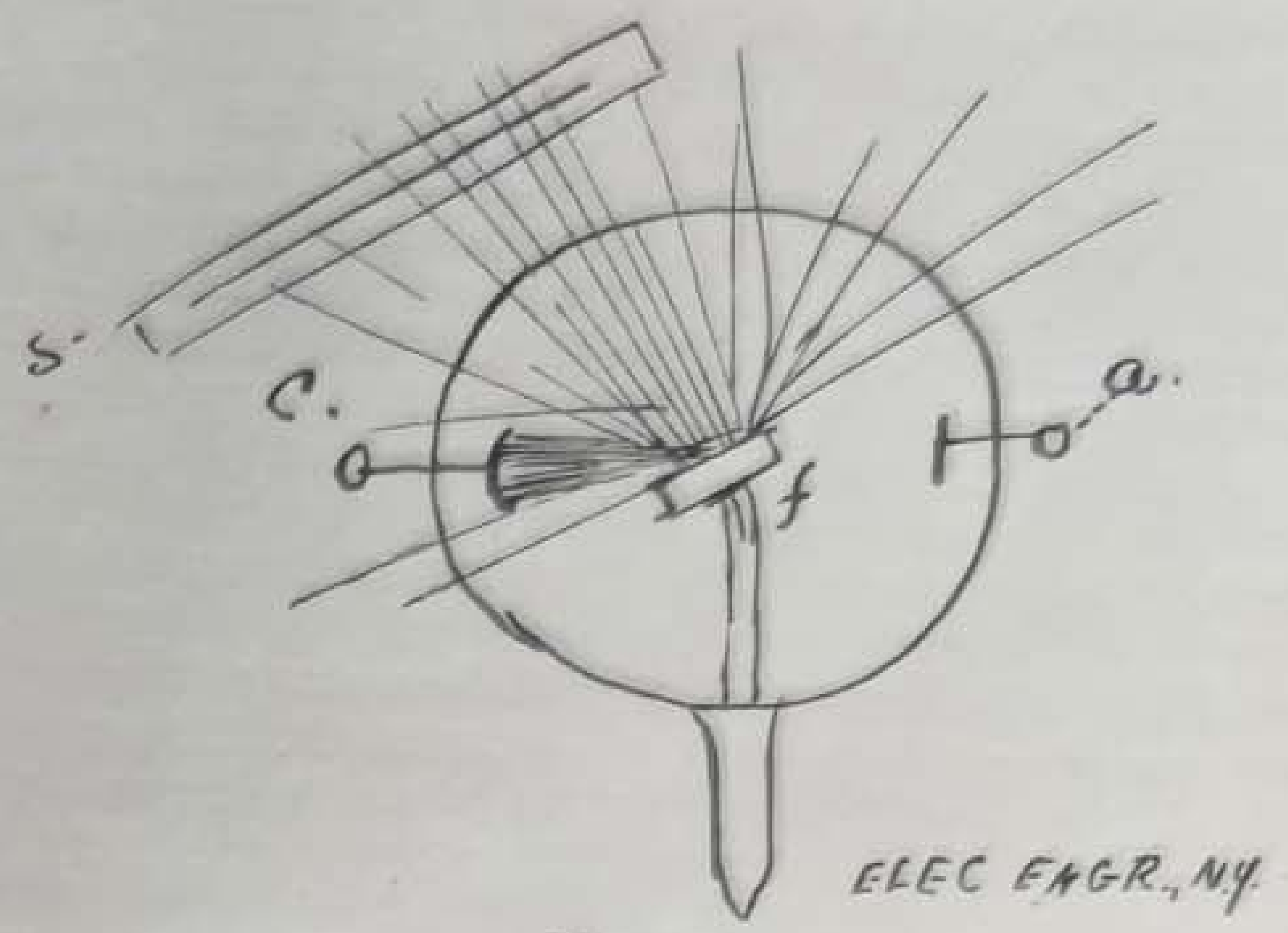


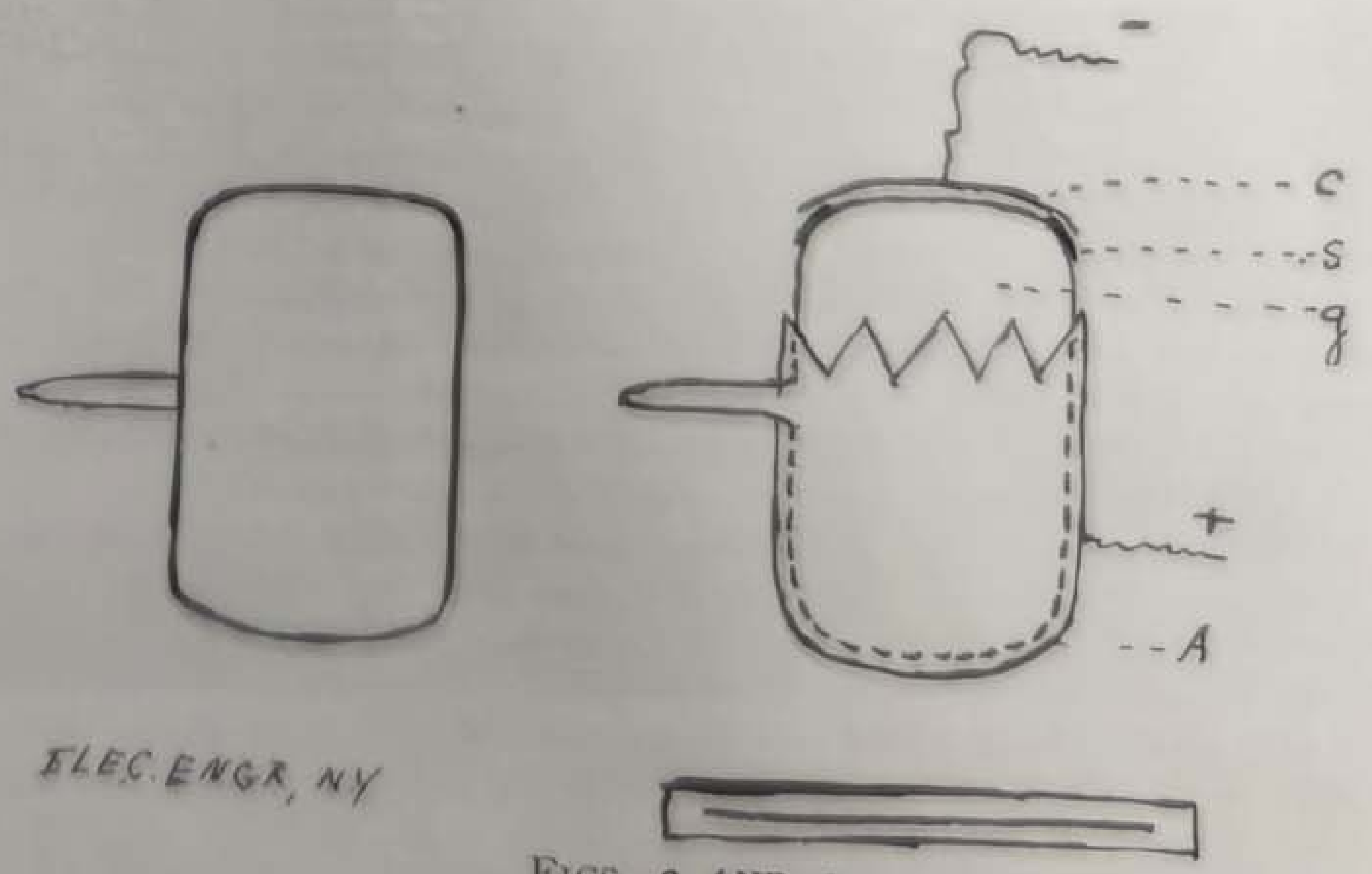
FIG. 2.

The anode, A, is also of annealed aluminum affixed to the glass bulb with mucilage and completely enveloping its end opposite the cathode and also its sides, with the exception of a small portion of the glass marked g. The anode thus forms practically a metallic cup, within which about two-thirds of the glass bulb sets.

The top of the cup is cut in the form of large serrations in order to provide for a possible sparking over between the two electrodes. If the distance between the two electrodes and the serrations are not properly arranged the glass may be easily perforated.

Running the static machine at fullest practical speed and employing Leyden jars one inch in diameter and seven inches long, coated with tinfoil over one-half of their length, I am able to excite the bulb with a spark extending over a spark gap at the discharging rods of one and one-half to two inches. The cathodic stream from C strikes violently against the opposite end of the tube and causes an active yellowish fluorescence. The sensitive plate is exposed, as indicated, opposite to the anodic end of the tube. The distances I have found most practicable are from 4 to 8 inches. I use a lead diaphragm at the anodic end, having an aperture of from one to two inches.

It will be noted that there is no window or opening in the anode and that the anode, or a considerable portion of it, intervenes between the cathode and the sensitized plate. Should a window be cut in the anodic metal with the hope of getting a better effect upon the sensitized plate the efficacy of the bulb will be greatly diminished.



FIGS. 3 AND 4.

My apology for presenting these details is that this bulb works well with a static machine (or with an induction coil) and that it may prove of interest to many who own such machines to construct their own X-ray bulbs.

The cathode is shown at C, Fig. 2; the anode at A; F, is a piece of fluorescing substance.

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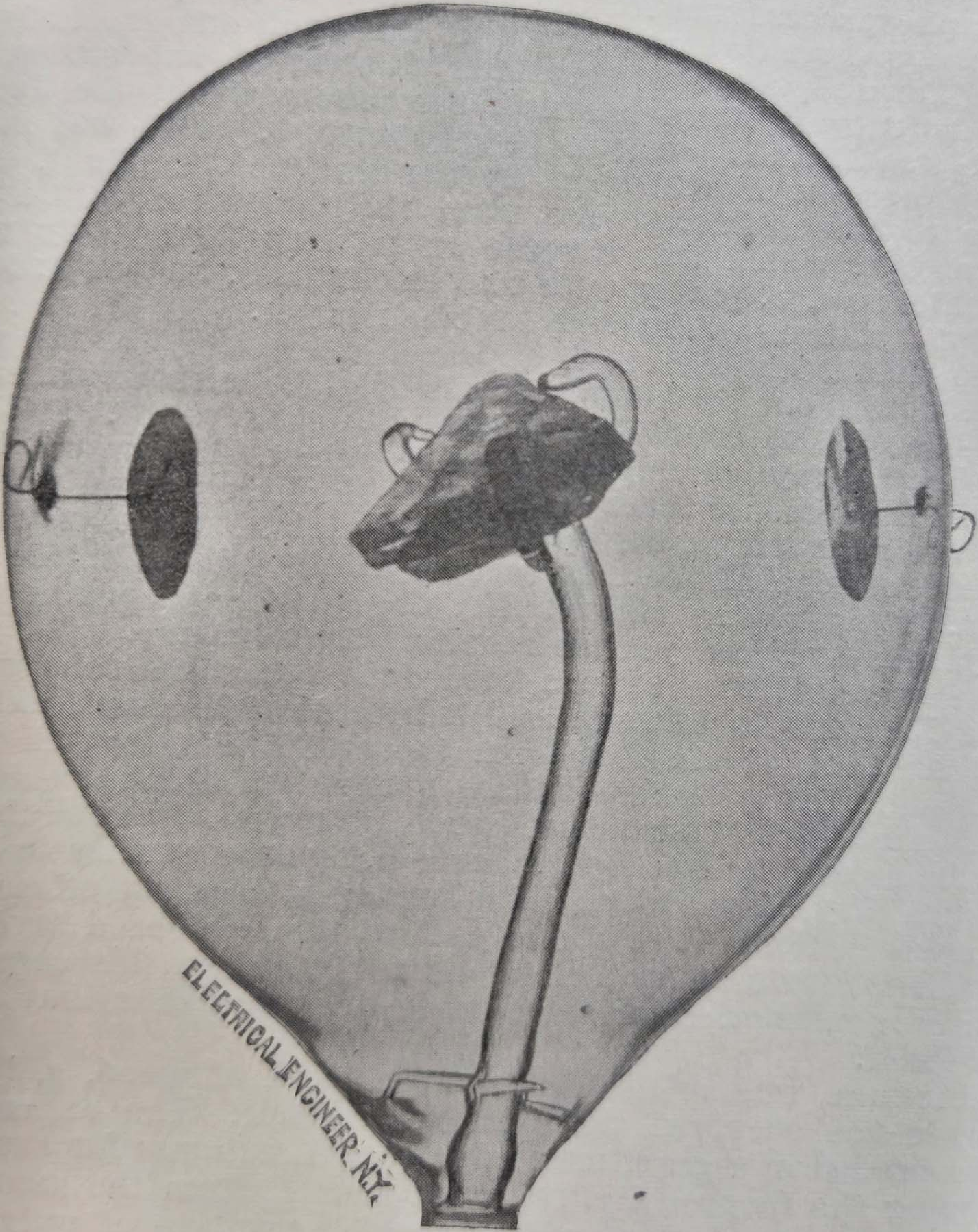

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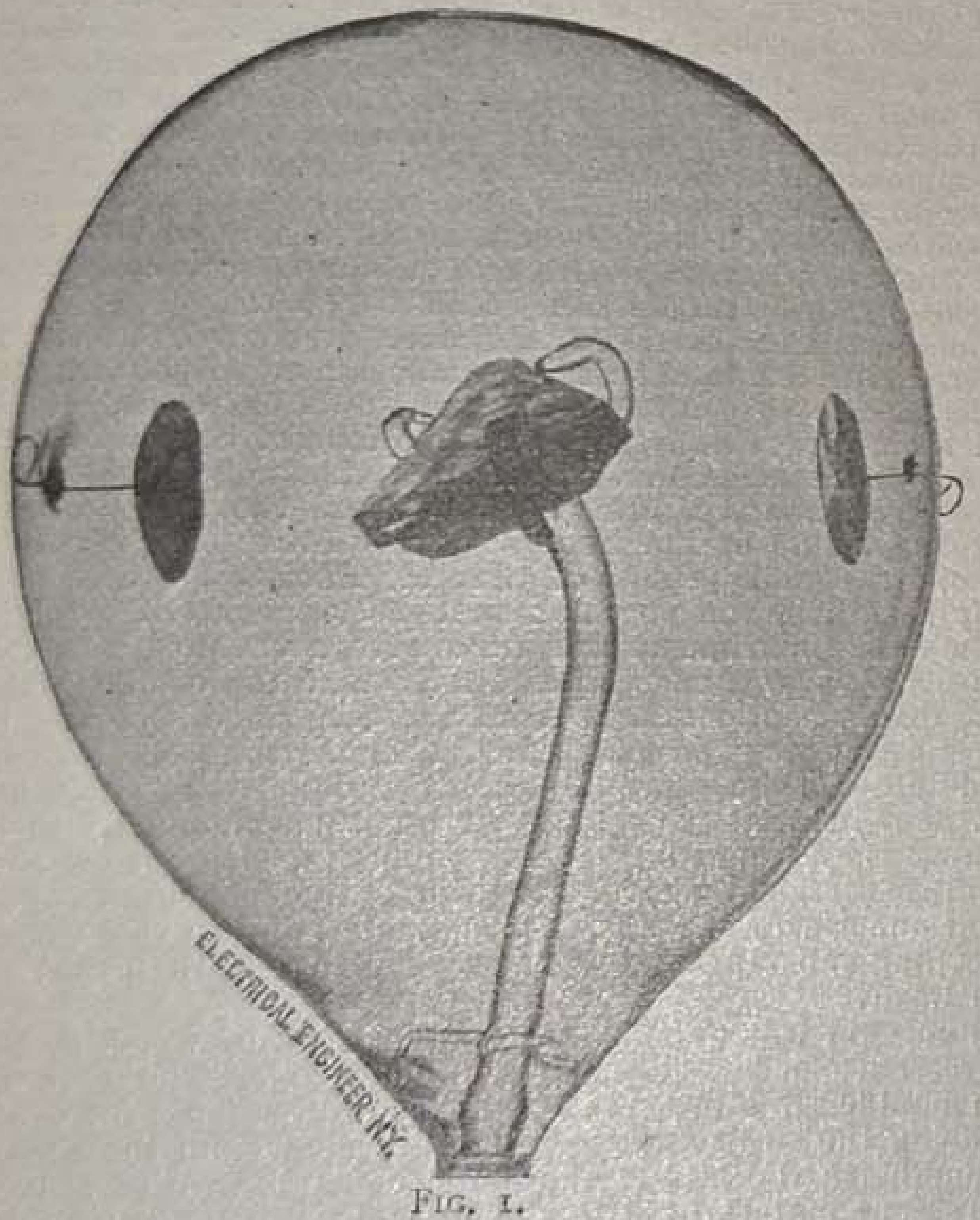

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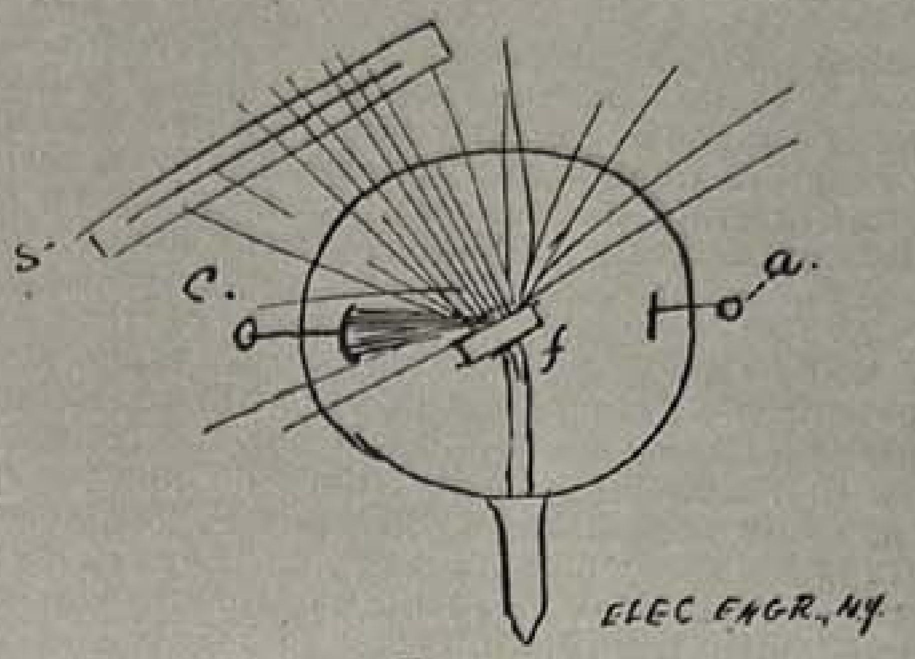

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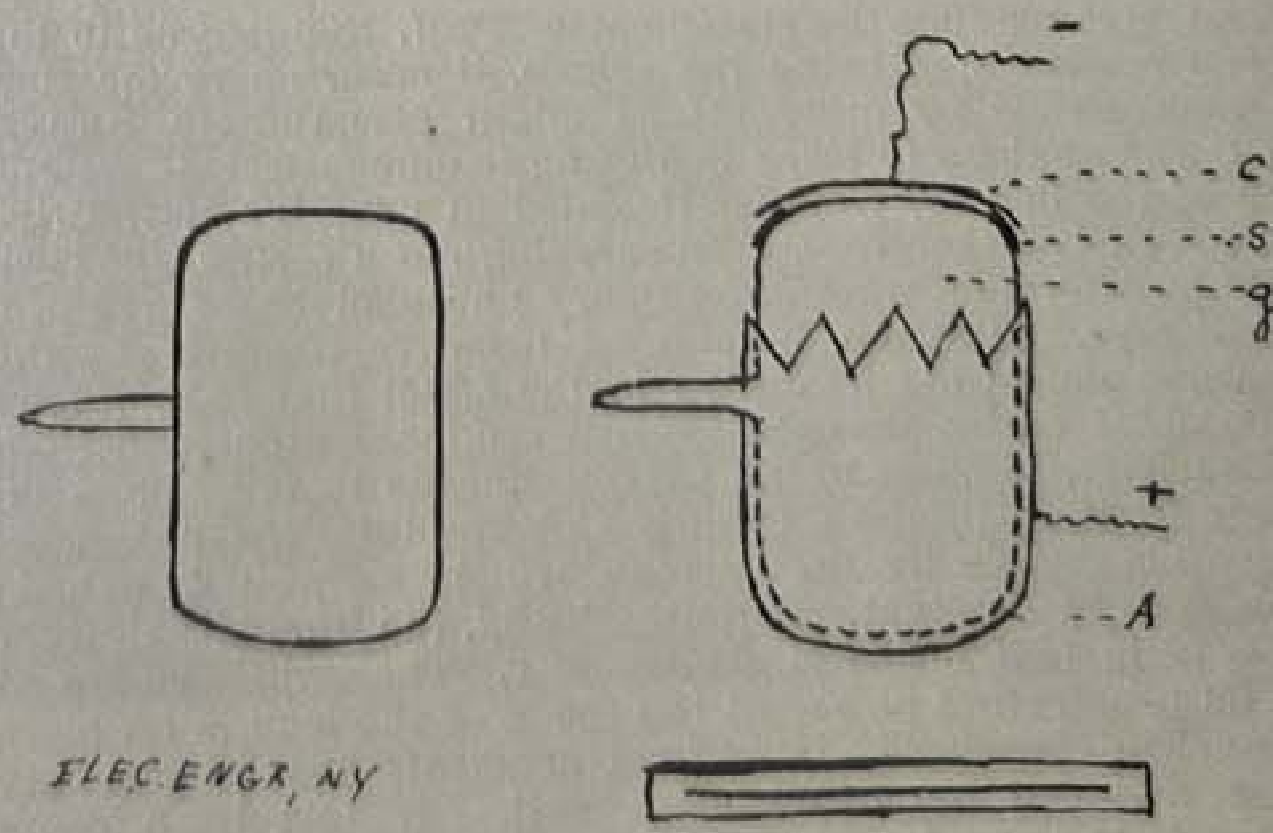

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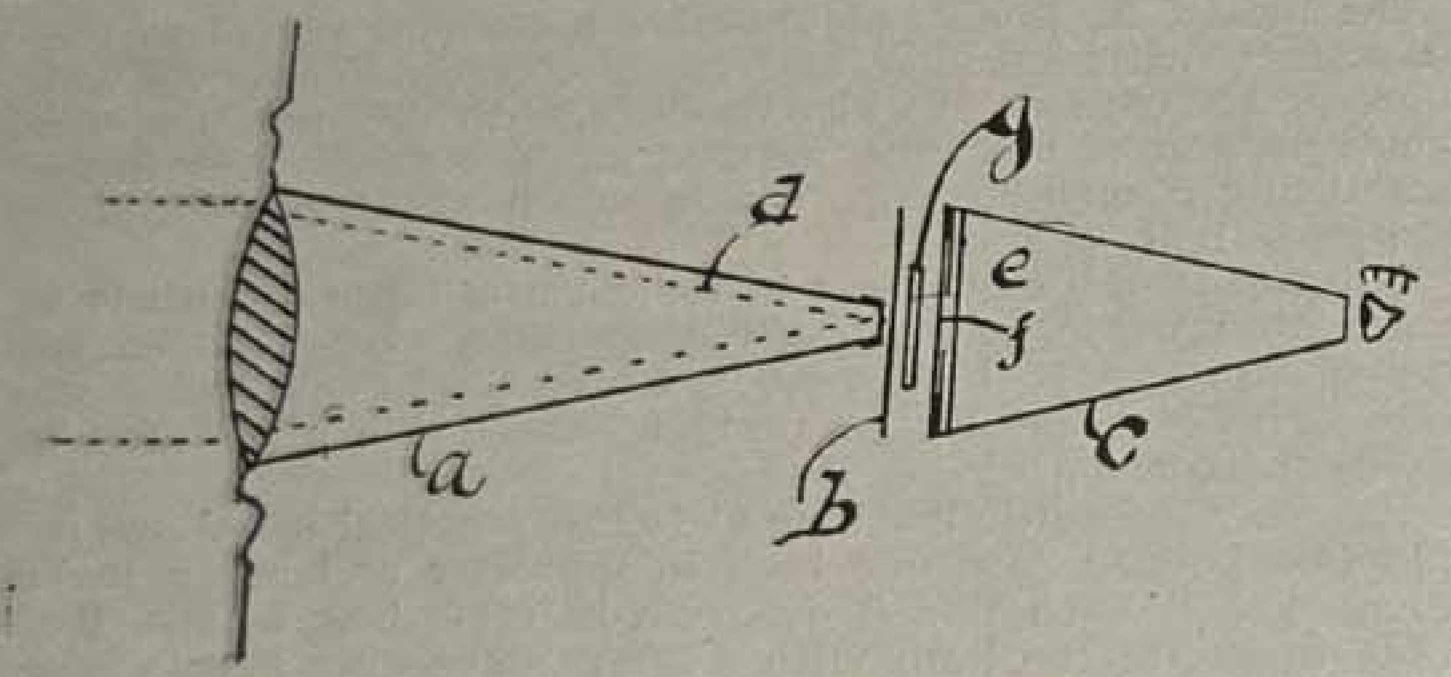
PHOSPHORESCENCE AS THE SOURCE OF X-RAYS.

BY EDWARD P. THOMPSON, M. E.

ONE of the most important facts necessary in order to determine the nature of the X-rays is that which will prove their source. In the first place Prof. Röntgen alleges that they radiate solely from the phosphorescent spot upon the Crookes tube. Dr. Morton's experiment indicates the same feature. M. Charles Henry thinks he obtained X-rays from a phosphorescent substance, which he exposed to the light. Niewenglowski finds that phosphorescent bodies increase the penetrating power of sunlight like the sulphide of zinc increases that of X-rays. Poincaré at an early date advanced the hypothesis that the rays are due to phosphorescence, whether produced by electrical or other means. Professors Thomson and Rowland maintain that they radiate from the anode. Tesla has obtained effects by a closed bulb without any electrodes. In one of Tesla's experiments, he employed only one and either electrode, while the other was away off in space somewhere, and yet he obtained penetrating power at great distances. He is convinced that phosphorescence is not the source, because he believes that aluminum X-ray tubes do not phosphoresce. He gave no other explanation. Silvanus P. Thompson thinks that certain of his experiments prove that the rays do not come from either the cathode or from the phosphorescent spot individually, but jointly from both.

I have obtained fluorescence from X-rays after they have passed through a fluorescent substance. Experiments have also proved, apparently, that there are no X-rays radiating from the arc light, sun, flames or other sources of light. Other experiments show that although a Crookes tube may phosphoresce, yet no X-rays can be detected. Sometimes the phosphorescent light is local, occuring in spots here and there. It may be near the cathode or anode, or between them, or as in a tube with which I experimented, the light was practically uniform on the whole surface, and a fluorescent screen was illuminated by all parts of the Crookes tube equally. Experiment also shows that with a given Crookes tube, the penetrating power of the rays seems to depend upon the electromotive force of the electrical energy, all other things remaining the same. Tesla, with his apparatus, has projected them through the thickest part of the human body, so as to affect the photographic plate.



DETERMINING THE SOURCE OF THE X-RAY.

Upon first reading the statement of Prof. Röntgen as to the phosphorescent spot being the source, it occurred to me that phosphorescence by other means might also radiate X-rays, and I was anxious to learn in the most emphatic manner the truth of the matter, whether it ended in negative or positive results. I have, therefore, been carrying out a series of experiments to determine whether ordinary phosphorscence will produce X-rays. Although I obtained negative results, yet the conclusion should not be drawn to the effect that X-rays may not be obtained by phosphorescence produced otherwise than by electricity, because by no possible means imaginable could I cause light to produce upon a Crookes tube the phosphorescence obtainable by the current, which, as well known, is visible even by daylight. Parenthetically, the intensity of light spoken of in text books is a misnomer. The light considered as to its penetrating power at the focus of the lens is no more intense than elsewhere. It will not penetrate anything to any greater distance by being condensed. It merely appears brighter to the eye, because there is more of it upon a given area, or because more of it has penetrated a given substance. The volume alone is greater.

To determine the degree of phosphorescence obtainable upon a Crookes tube by direct sunlight, it was placed inside of a box having an opening covered by violet glass. When the box was looked into, so as to exclude all other light the tube did not even appear green. However, under the same circumstances, uranium glass, barium platino cyanide, also a screen of ammonium uranate, potassium platino cyanide and others appeared of a vivid green or yellowish green. The experiment was repeated with focused sunlight on a very large [illegible] the lens being about five inches in diameter and having a focus of sixteen inches, and provided also with a funnel [illegible] inside, which brought to a focus much diffused sunlight. The small end of the funnel was located in a dark room. The [illegible] was condensed upon violet glass.

The light passed through the glass, and, upon striking the phosphorescent and fluorescent materials, its refrangibility was changed; while the substances were as vividly green when produced by the radiations in the Crookes tube, [illegible] light cannot cause the same phosphorescence upon a Crookes [illegible] tube did not become green. Uranium glass seemed as [illegible] as when forming a Crookes tube highly charged. The Crookes tube had been before tested, and showed a green phosphorescence with a high electromotive force. The experiment with violet glass, although perfectly simple, and although the results, perhaps, could have been conjectured, proves that sunlight cannot cause the same pohsphorescence upon a Crookes tube as that produced by the current.

Another experiment indicated somewhat otherwise. In the direct focus, without blue glass, a livid green (as when electrified) was discernible as a fringe around the focus.

Inasmuch as the other substances fluoresced better with violet light than with the electrified Crookes tube, as far as the eye could remember, an experiment was performed with the apparatus shown in the accompanying diagram, in order to determine whether condensed sunlight would produce sufficient phosphorescence for the generation of X-rays. The funnel above described was closed at the small end successively by different phosphorescent and fluorescent substances. The instrument which has now become known as the fluoroscope was directed towards the substance, b, which was made phosphorescent or fluorescent by the condensed sunlight, in order to detect fluorescence upon the screen, e, within the fluoroscope, which was covered at the large end partly with one thickness, b, partly with two thicknesses, and on another portion by three thicknesses of black paper.

The fluorescent screen, f, appeared green only at the part covered with one thickness. It was brighter without screens, which seems to contradict Niewenglowski's result. If there had been X-rays of any appreciable extent, they would have caused fluorescence through the three thicknesses and through a block of wood, g, interposed between the two fluorescent screens outside of the fluoroscope, as illustrated in the diagram. It should be noticed that the fluoroscope was exceedingly sensitive, and yet the results were negative.

The same instrument was tried with a Crookes tube generating X-rays by a current, and it became uniformly luminous at a distance of six feet from the electrified Crookes tube; therefore, it may be concluded, I think, that X-rays cannot be obtained from phosphorescence produced by sunlight. It may be noted that the objects were not placed exactly in focus because they would burn. The funnel, a, was cut off so that the cross sectional area of the path of the condensed rays was about one-fourth of an inch in diameter, and in this case the absorbing substances were not needed further than that of the lens itself.

Aluminum was substituted for the block of wood, g, but no fluorescence occurred with the fluoroscope. The experiment was modified in a great many different directions; for example, by using the focused light when reflected from the screen, although (as the latter was made of a mixture of pulverized fluorescent material and varnish) the fluorescence was caused by reflection from each particle when the light was transmitted by the screen, as well as when reflected therefrom. A gas flame was also employed as a source of light; also sunlight without a lens.

Remembering how a little daylight entering the eye while viewing fluorescence by X-rays nearly neutralized the effect, I thought, perhaps, persistence of vision prevented my seeing any fluorescence which might have been produced through the three thicknesses of black paper, and therefore I applied the most severe test. A photographic plate with a metal disk attached to it was wrapped closely in several folds of black paper and inclosed in an aluminum box, which, in turn, was wrapped in cloth. On the outside of all was fastened a plate of uranium glass, which was exposed to direct sunlight for over seven hours. No effect whatever was produced upon the photographic plate. With X-rays, an effect would have occurred through the same thickness in a few minutes.

A large glass plate covered with calcic sulphide, which remains luminous in a dark room after having been exposed to sunlight, was tested. I exposed the plate to the condensed sunlight, forming a bright, luminous spot, and at another time I exposed the whole plate to sunlight for an hour or more. When the fluoroscope was directed toward it in the dark and certain experiments performed, sufficient light was produced

ROENTGEN RAY LAMPS AND OTHER EXPERIMENTS.

BY

Thomas A Edison.

A VACUUM tube, the inner portion of which has fused to it crystals of tungstate of calcium when exhausted to the X-ray stage, gives out scarcely any of the rays; on the other hand, the tubes shine with a splendid white fluorescence. We have here a true fluorescent lamp, possibly commercial, as a very small bulk gave in the photometer 2½ candle power with an extremely small amount of energy. The white light is of a character not unpleasant, but quite the contrary. The spectroscope reveals the reason; the spectrum has strong red rays.

Tubes with aluminum electrodes become coated with transparent aluminum, which, as time goes on, gets so thick as to become visible. The X-ray is greatly diminished, not, I think, so much on account of absorption of the wave after generation, but through lack of elasticity, the concussive action or energy being absorbed by deforming the aluminum.

Silicon carbide is a conductor for high-tension current, a fact previously noted by Tesla. It is a very good conductor. I have substituted pieces of the carbide for aluminum; no air comes therefrom; it does not absorb air; it cannot be melted, nor does it blacken the glass. The voltage can be increased to a point where the glass melts. It may possibly prove the most practical substance for electrodes in high vacua. The only difficulty is the contact between the carbide and platinum wire.

With all glass used for making bulbs the sodium line shows in the spectroscope; there is evidently a decomposition due to the current, electrolytic or otherwise. Combustion tube glass has the least; lime soda glass, that is, the glass used for dry plate photography, has the most. This latter glass is the most transparent to the X-ray, but the continuous decomposition of the glass makes it almost impossible to maintain a vacuum except when connected to the pump, and even then the effect of the current is greater in producing gas than the capacity of the pump to exhaust, but the ray is very powerful.

Experiments were made with over twelve hundred substances in the form of crystals and precipitates. Not one fluoresces through thick cardboard when the sources of energy are the arc light, a six-inch spark in air, a vacuum tube with vacuum so high that a ten-inch spark leaves it dark, and the direct rays of the sun from 11 till 2 p. m.

Another fact supporting the theory that the X-ray is a wave due to concussion is that crystals of calcium tungstate are very sensitive to agitation or slight friction, giving off light. It is also of interest to note that by a properly arranged sensitive flame and phonographic listening tubes, my assistants have made it responsive to the X-ray.

THE DOEHN CARBON CONSUMING CELL.

A new proposal for making a galvanic cell consuming carbon was made by Dr. A. Coehn, in a communication to the Elektrotechnischer Verein of Berlin, on February 25th. The "Elektrotechnische Zeitscrift" for March 12th makes the following remarks on the subject: "The investigation is based upon a fact which has been already observed by several other electrochemists, but which has so far been found very inconvenient in electrolytical processes in which insoluble anodes are required. The carbons mostly employed have not, under the influence of the current in different liquids, shown sufficient resistance to disintegration. On the contrary, the carbons fell to pieces. In proceeding step by step and with experiments well arranged, Dr. Coehn has been able to find out the exact conditions required to enable the carbon to produce on oxidation only carbon dioxide (CO_2) and carbon monoxide (CO) on the anode. It was found that a certain temperature and a certain current density were necessary conditions, as electrolytic diluted sulphuric acid of a certain gravity was used. Dr. Coehn was further successful in depositing on the cathode the carbon given off by the anode. This proves that the carbon or a compound of it plays an important part in the transport of the electricity through this liquid. To construct a cell which is based on the combination of carbon the necessary oxygen must be supplied to the cathode. This is done by employing peroxide of lead cathode. In such a carbon cell with sulphuric acid, the carbon burns

on the cathode

ARE ROENTGEN RAY PHENOMENA
WAVES?

BY PROF. WM. A. ANTH

THE observations of Mr. Edison, recorde
The Electrical Engineer of April 8, d
me to warrant the conclusion at which he
known that sound shadows are not as sha
shadows and the reason is that the wave le
very great compared to those of light. Th
lengths the sharper should be the shadow
should the geometrical shadow be enc
radiant energy. Now the geometrical sha
arranged as in Edison's Fig. 1 would be
lines a a'. Rays deflected into the shadow
figure, could not have been due to a true di
have been due to some other cause.

The experiments of Le Conte, to which Mr. E
far from warranting the conclusion that
his own experiment seem to me to show tha
could not be due to diffraction, and therefo
upon the question as to the nature of the R
Le Conte's experiments show comparati
shadows. Even at a distance of twelve fe
only one foot in diameter, casting the shado
apparent penetration within the geometric
any such effect as Edison shows had occu
should have been completely obliterated at
the pile.

The beautiful experiments of Professor Stine
and M'Berty indicate a straight line propaga
gen radiations, and go far to prove that th
by Edison must have been due to some other
to which he ascribes it. These experiments
adapted to demonstrate th source of the Röntg
us back to the conclusion originally announce
himself, which has always seemed to me to b
notwithstanding all the different conclusions
drawn from later experiments. These results
carefully Röntgen had studied the phenomena
his original announcement.

These experiments seem to demonstrate
the source of the Röntgen radiations is the
face of the glass. It is probable, as suggested
Elihu Thomson, that this bombardment produ
one the Röntgen radiations and the other pho
glass, and that the greater the phosphoresc
Röntgen rays.

I have always wondered why some of the
menters upon these phenomena have not made
demonstrate, first, whether the Röntgen radiati
gated as waves, or are flying particles shot off fr
and, second, if waves, what is the wave length
wave motions, whether the vibrations are
transverse, the fact should be capable of
diffraction phenomena. Professor Snow, of the
University, has suggested a method by which th
be made.

A parallel beam of rays might be obtained by
vibrations to pass successively through two
lead screens placed a little distance apart. Th
received upon a grating consisting of finer copp
parallel to each other, should, if the radiations
tions, give diffraction phenomena that would de
fact, and also furnish data for computing the wa
the radiations consist of a few definite wave leng
question whether those radiations are wave m
actual translation of particles, seems to me the
tant one to be settled at this stage of the investig
hope some one will take the matter up.

PROPOSED MUNICIPAL PLANT FOR UTI

Professor E. P. Roberts has estimated $114,0
of a municipal plant for Utica, to furnish 500
M. H. Johnson, a local electrical engineer, has es
441. The assumed operating expenses are respe
and $44,996.

"W

THE
Electrical Engineer.

Vol. XXI. APRIL 15, 1896. No. 415.

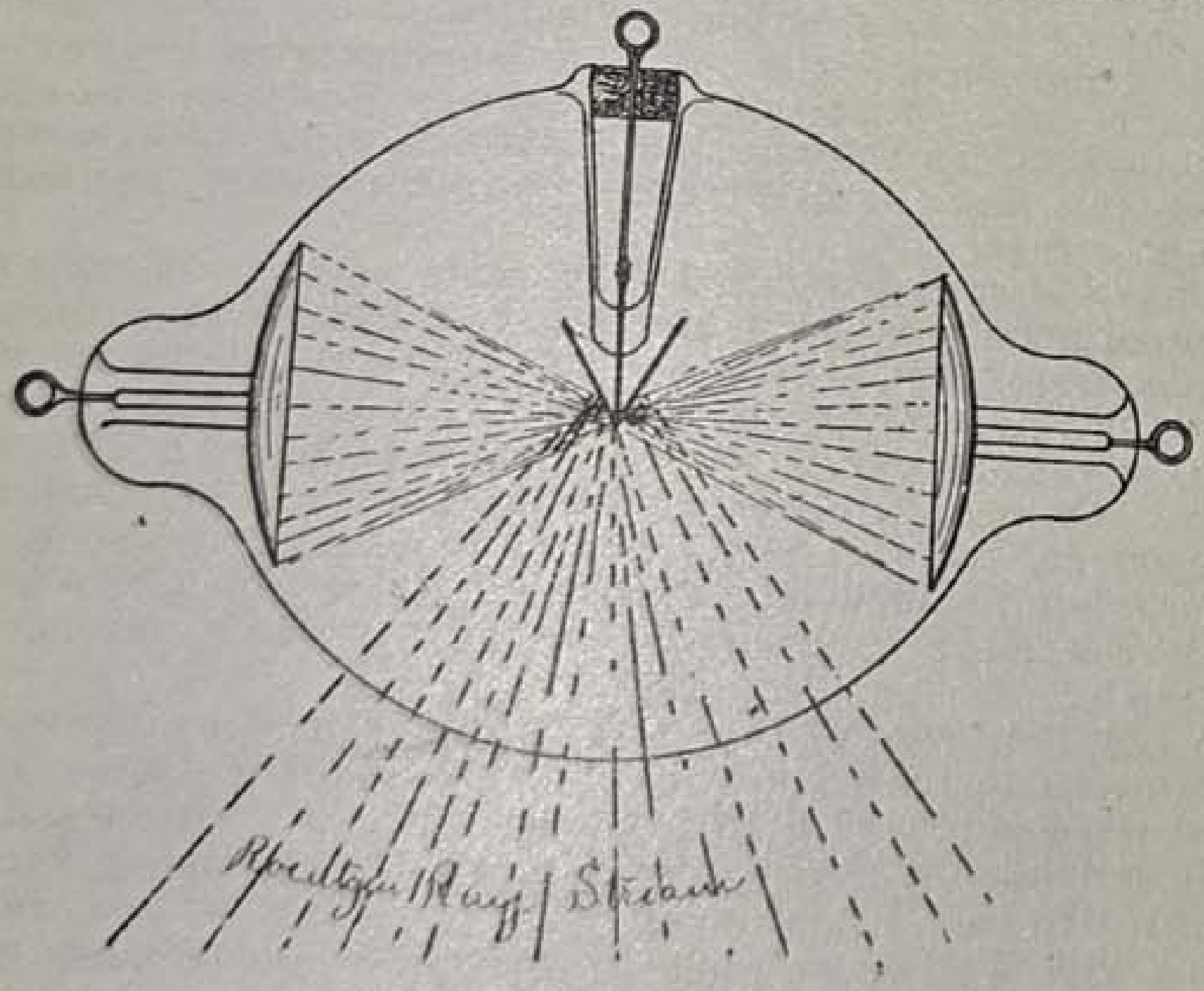
ELECTRIC LIGHTING.

A STANDARD FORM OF ROENTGEN RAY TUBE.

Elihu Thomson

MY attention has been called to an article by Mr. T. A. Edison on "Are Röntgen Rays Due to Sound Waves?" published in "The Electrical Engineer" of April 8. In the first place, I would say that I thoroughly appreciate the arguments advanced by Mr. Edison in relation to this matter, but if I understand him to put forward the idea that Röntgen rays are simply sound waves of very high or inaudible pitch in air, solids, gases, or liquids, then I think there are certain facts which negative any supposition of this kind. Röntgen rays traverse without apparent absorption highly exhausted bulbs, or bulbs which contain the least possible air or gas. This fact alone would point to the Röntgen ray as propagated by ether and not as a sound wave in air. It would be very difficult to explain on a sound-wave theory how some substances are electrified positively and others negatively by Röntgen rays.

If Mr. Edison means that the waves are longitudinal waves, and not transverse waves in the ether, and, therefore, analagous to sound waves, this, of course, would not be a new view, as it has been advanced by Prof. Röntgen himself, though there are many facts which have since been discovered which tend to favor the idea that Röntgen rays are simply very high pitch waves similar to light waves; that is, transverse waves in the ether.



PROF. ELIHU THOMSON'S STANDARD RÖNTGEN RAY TUBE.

The experiments with the steel plate which Mr. Edison describes appear to me to indicate something in the nature of diffraction. Some of the earliest Röntgen pictures which I made gave evidence of a slight amount of reflection of the rays at high angles, at least the appearances presented, could only be explained on the idea of reflection. The rays found in the shadow towards the edge of the steel plate in the experiments of Mr. Edison may have been due to diffraction.

My observations in regard to the Röntgen rays from tubes with even so low a vacuum as to give striae coincide with those of Mr. Edison—that such tubes will even give Röntgen rays when subjected to very sudden discharges, that is, discharges in which the potential wave thrown upon the tube is abrupt. Hence, a Wimshurst machine will excite such a tube where an induction coil may not. The sharpness of the shadow
given by a Crookes tube will depend upon the definiteness of
the bombardment, that is, upon some particular spot alone
becoming the source of the Röntgen rays, and upon the char-
acter of the discharge, which, if oscillatory in character will,
in many tubes, produce two sources of emanation of Röntgen
rays, and this, of course, will give confusion in the image.
An abrupt break in the Ruhmkorff would naturally tend to
give prominence to a particular direction of discharge, and,
hence, conduce to making one of the terminals more entirely
a cathode than with a less abrupt break in the primary, sharp-
ness being the natural result.

I may add that the observations which have up to this time
been made as to the source of the rays point to the fact that
the cathode rays must strike some surface, which then be-
comes the Röntgen ray source. My own observations make me
think that if the bombarded surface is of such a dense metal
as platinum, which does not fluoresce, the rays will be more
energetic. Bearing in mind these considerations and that it is
desirable to possess Crookes tubes which are of standard
make and adapted for use with high frequency apparatus,
Ruhmkorff coils with oscillatory or uni-directional discharge,
or with Wimshurst or Holtz machines, I have proposed as a
standard tube one which is represented in the accompanying
sketch.

The structure consists of a bulb, at opposite sides of which are mounted concave aluminum discs supported on wires sealed through the glass. The foci of these concave electrodes coincide nearly at the center of the bulb, at which point is located a V-shaped sheet of platinum, iron, or other piece of metal, such as a small piece of iridium. This could be supported in any way desired, but it may be suggested as a convenience that it be mounted on a third or middle terminal, so that it can be made an anode. In using this tube with high frequency currents the two cup-shaped terminals are attached to the source of electric currents, which alternately become cathode during the discharges, and cause the Röntgen rays to be emitted from the apex of the platinum sheet or from the surface of the piece of metal placed at the common focus. With oscillatory currents from a Ruhmkorff coil the same connections may be used, and even when the discharges are uni-directional the connection of either cup-shaped terminal as a cathode makes the tube effective, but in this case the middle terminal may be made the anode and the other or cup-shaped terminal a double cathode, and thus give the greatest amount of cathode surface, with but a short distance to be traversed by the discharges, while the sharpness of the focus, and consequently the definition obtainable with the Röntgen rays remains unimpaired. If the vacuum in such a tube is too low, it is also possible to raise it quickly by constituting the middle terminal a cathode for a time, in which case metal would be carried therefrom and deposited on the side of the bulb in a very fine state of subdivision and quickly absorb the residual gas. During the working of the tube it can sometimes be restored by simply heating the tube to a high temperature.

WAS THIS LAND LIT BY X-RAYS?

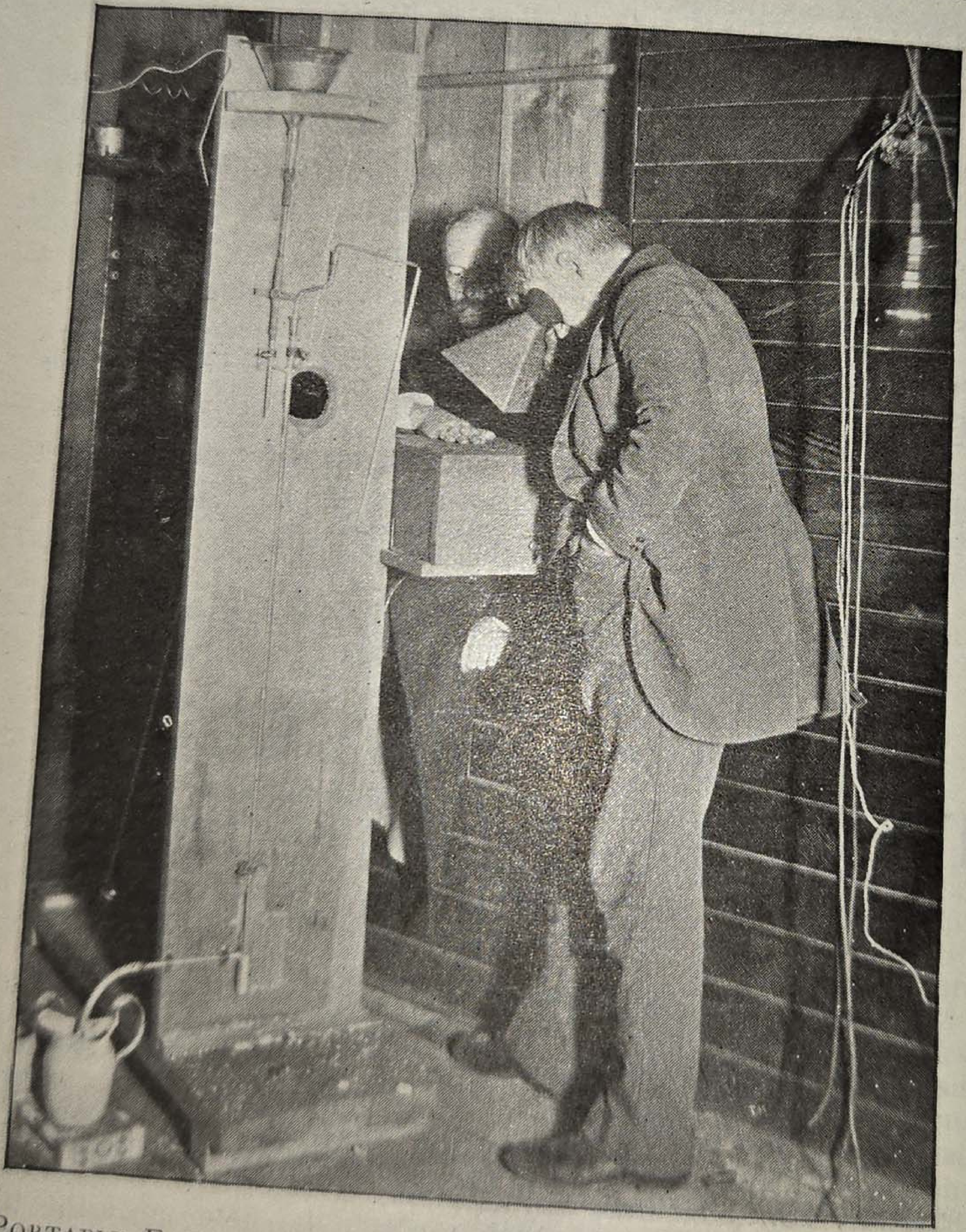
A reader of "The Electrical Engineer" sends us the following bit of folk-lore taken from the book entitled "Stray Leaves from Strange Literature," by Lafcadio Hearn: "There is in the ancient Finnish tongue a strange book written, called 'Kalewala,' a book of runes, treating about the beginning of the world, and about the god-smiths who first wrought the foundations of the sky, and about the witches and enchanters of the farthest North. Of witches Louhi was among the greatest, and her daughter was wooed by gods and heroes, even by Wainamoinen the mightiest. * * * So fair was the virgin that her beauty gave light like the moon; so white were her bones that their whiteness glimmered through the transparency of her flesh; so clear was the ivory of her bones that the marrow could be seen within them. * * * And the story of how Wainamoinen built a boat that he might sail to woo the virgin, is told in the runes of the Kalewala."

great many friends. He leaves a widow.

EXHIBITION NOTES.

EDISON'S PORTABLE X-RAY APPARATUS.

In addition to devising his simple and highly ingenious fluoroscope, based upon the properties of tungstate of calcium, enabling anybody to examine at will any object, whether moving or still, under the Röntgen ray, Mr. Edison has now put together a simple compact set of apparatus, by means of which the whole fluoroscopic and ray outfit can be carried from point to point and utilized on the spot for surgical operations and physical introspection. Mr. Edison is now building four of these sets which will be operated by his own staff in the Röntgen ray exhibit which he has very generously consented to make at the National Electrical Exposition in this city.



Portable Edison Fluoroscope Apparatus to be Used at the Electrical Exposition.

The picture shown herewith, taken from a flashlight photograph, made last week, is of Mr. Edison himself, at the Orange laboratory, studying a hand by

The hand rests

WHAT EXHIB

ACTIVE preparations for
Grand Central Palace
who have their plans well
they propose to do.
The General Electric Comp
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The New York Edison Com
undertaken to show on a br
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office, factory, hall, street an
The Abendroth & Root Ma
in a fine boiler plant, which
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one of the most striking feat
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about placing on the mark
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Self-Oiling" engine, and it
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NEW YORK

Mr. W. H. Bonnell, the

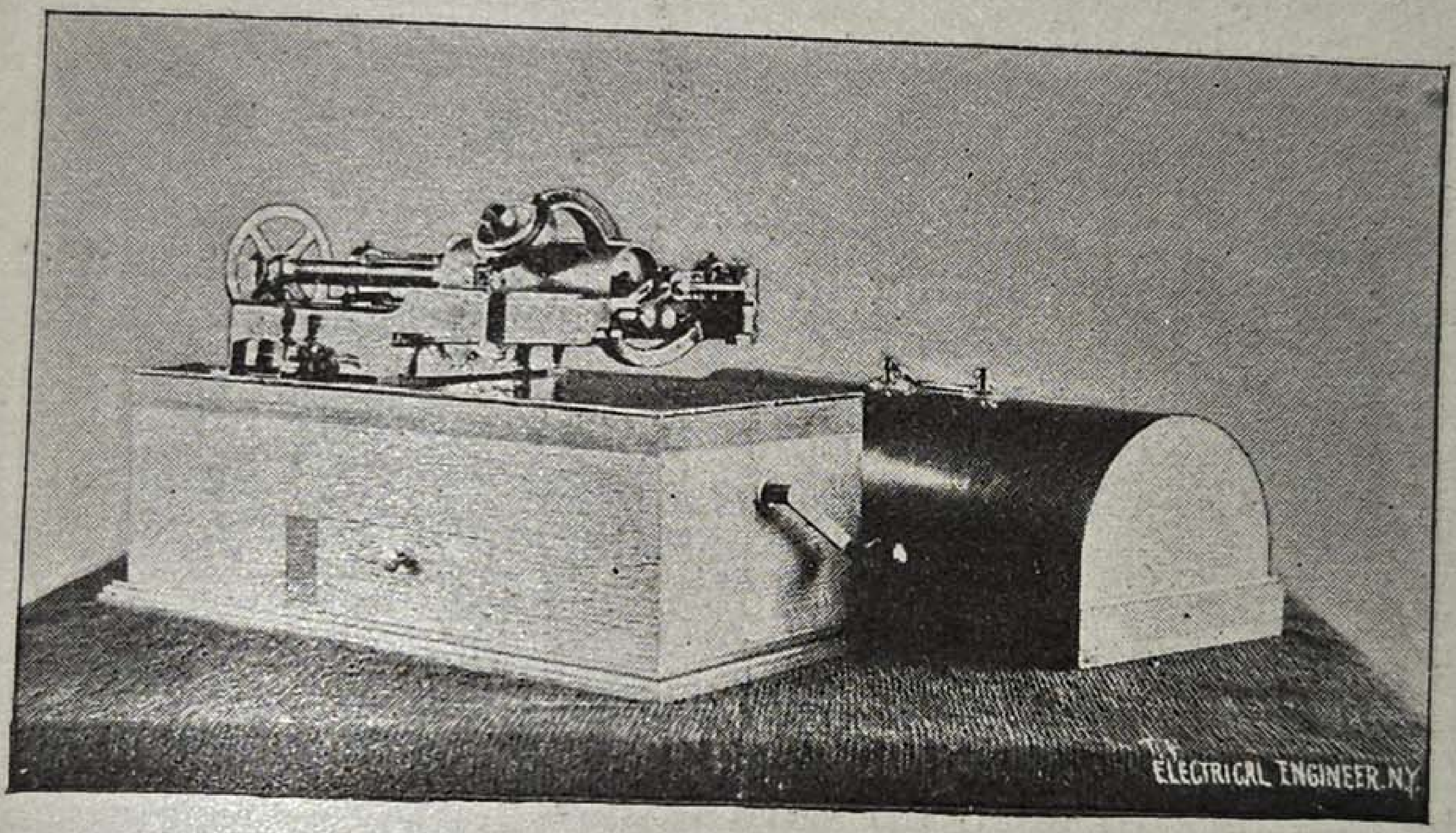
Trade Notes and Novelties

AND MECHANICAL DEPARTMENT.

A NEW EDISON PHONOGRAPH.

THE recent announcement of the interesting news that Mr. Edison had bought back from the receiver of the North American Phonograph Company his own property and rights, is followed up by the placing on the market of the new Edison phonograph here illustrated. This machine is being built at the Edison Phonograph Works, at Orange, N. J., and will be handled by the National Phonograph Company, which is now establishing agencies everywhere for its sale.

The new machine conforms in a general way to the older type, but it has two decided elements of novelty. One is that it is operated by a spring motor, and the other that it is to be sold for about $40, thus placing the instrument within the reach of everybody, as a very formidable rival to the limited musical box. Mr. Edison has found that many people are still unable to avail themselves of street current for the dearer phonograph run by electric motor, or else are very averse to bothering with primary batteries, which few of them understand. Hence, he has deemed it advisable to build this new phonograph, which is driven by a simple double spring clockwork mechanism packed away snugly under the lid of the box. The phonograph is similar in design to the standard instrument, but is in reality lighter and thus runs with less frictional loss. The thread on the main shaft is 100 to the inch, so that the standard music and recitation cylinders, of which there are now thousands, can be used. It is so arranged that multiple tubes can be employed, enabling several persons to listen at once; and it is also furnished, when desired, with a large horn and stand, answering the needs of a large audience. The size over all is 15½ by 7 inches by 10¾ inches in height. The machine is fitted with a handsome oak case, having a removable halfround top and a drawer for supplies. The whole thing is remarkably compact, and the results given by the machine are wonderful in clearness and sweetness of tone. The machine is fitted for reproducing only, but for a small extra charge it is also built to record, or to do both.



THE NEW EDISON PHONOGRAPH.

J. H. McEWEN MFG. CO.

Those who are contemplating the installation of steam and electrical apparatus should send for the handsome catalogue

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THE INTERNATIO

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SUNBEAM LAMPS

THE Sunbeam Inc
making a speci

RECENT DEVELOPMENTS IN VACUUM TUBE LIGHTING.[1]

BY D. MC FARLAN MOORE.

MOST people have been accustomed to oil lamps, gas jets and other forms of light which have about reached their perfection. With the appearance of the arc and incandescent lamps it was thought that electricity had reached its limit in giving to the world a system of illumination that would leave nothing more to be desired. Indeed, it seems almost a presumption to dare to think of light being produced that would approach daylight in form and quality. The time is not so very remote when any man who would have attempted to manufacture sunshine would have shared the fate of a Galileo.

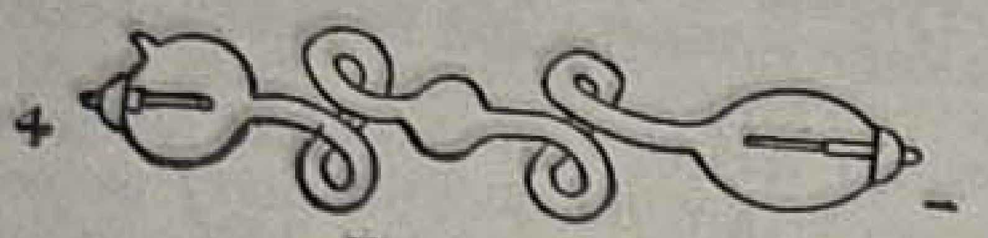

FIG. 1.

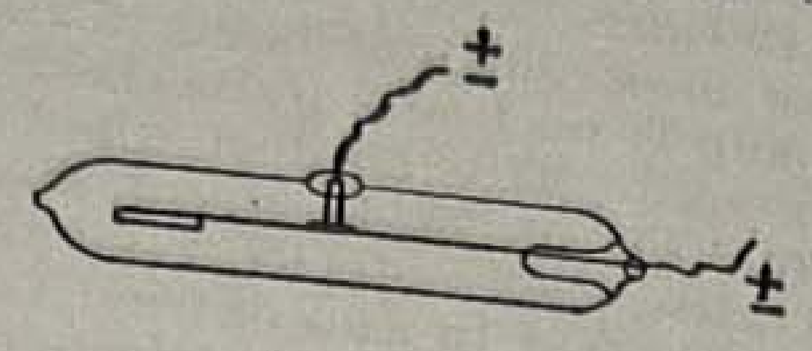

FIG. 2.

But fortunately the investigator of to-day has nothing of this kind to fear. Much arduous labor has already been expended in the solution of the problem by many eminent electrical scientists engaged in the study of vacuum tube phenomena, but the results from a practical point of view have been very meager. This is chiefly owing to the complicated and expensive apparatus necessary, and the very unsatisfactory results even then obtainable. In fact, light from vacuum tubes, which is the only form of illumination that actually approaches nature's standard—daylight, has never been obtained in any quantity that would, in any way, be suitable for practical use. Of the other forms of electric lighting, the incandescent lamp is the most prominent. It is the peer of all illuminants in commercial use to-day, but is lacking, when we consider maximum uniformity in the distribution of light, and when calculations show that only three-tenths of 1 per cent. of the energy of the coal necessary to produce light by incandescence (its name defines its character) is actually transformed into light, it is evident that there is room for improvement. The new electric light should possess all the good qualities of the present lamp with none of its drawbacks, and among its improvements will be noted the combination of utility and decoration. The recognized tendency of the day is toward multiplication of lights and avoidance of strong shadows—in other words, an even illumination, that is, light from all directions.

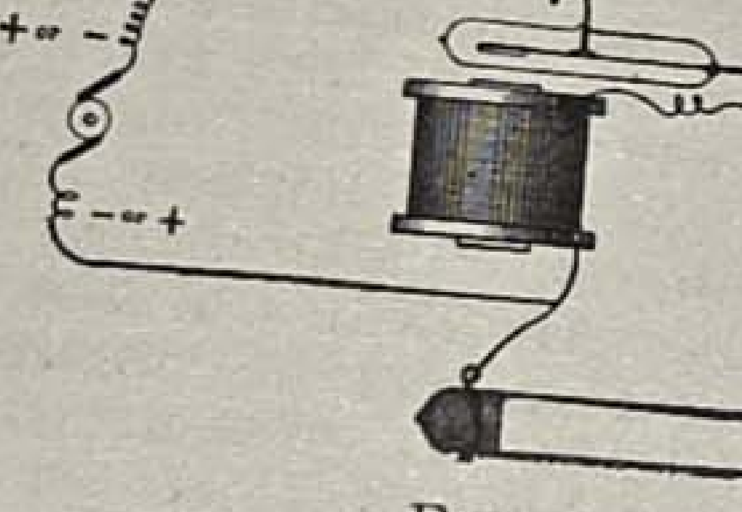

FIG. 3.

The object of this paper is not only to call attention to the advantages that will accrue with the adoption of vacuum tube lighting, but more particularly to a simple method of obtaining a current which will ultimately make such an adoption universally feasible. Almost without exception, experimenters in vacuum tube lighting have hitherto sought for the solution of the problem by merely pushing to extreme well-established methods based on principles long known in the art. That is, strictly speaking, no radical departures from the well-beaten paths have been as yet brought forward. However, this paper does represent radical departures: in principles, in apparatus and in the nature of the current, resulting in a light of greatly increased intensity.

Before entering upon a description of the new system, permit me to call your attention to the methods heretofore used for obtaining light from hermetically sealed glass tubes containing a rarefied gas.

For many years the Geissler tube has been a scientific toy. When a suitable electric current is connected to its terminals, its entire length is filled with a faint glow. This is, of course, a light of radically different character from that now used in any commercial form of illumination. (See Fig. 1.)

It is light emanating from rarefied air with an apparent absence of heat and combustion. Upon this principle developed, probably depends the light of the future, which will soon be, in the opinion of the writer, the "light of the present." As a device for transforming electrical energy into light, the vacuum tube is very efficient. The majority of authorities place it at about 70 per cent. and the incandescent lamp at 2 per cent. Notwithstanding this remarkable efficiency, it has never been commercially possible to illuminate by vacuum tubes, because the light could not be made sufficiently intense (this is expressing it mildly) even with bulky apparatus that was entirely impracticable.

Furthermore, the current produced by such apparatus was of such a nature as to render its insulation extremely difficult. The ordinary induction coil is often used for this purpose. A current of low voltage, such as that from a battery of a few cells, must be used with such a coil, because a current of higher voltage could not be properly disrupted, the arc forming preventing a sudden break of the current. But since the light depends on the suddenness of the break, the arc must be prevented, therefore the quicker the break, the brighter the light—provided the apparatus is properly designed.

The quickest break can be made by interposing in a circuit the most perfect dielectric in the minimum space of time. The best dielectric known is a vacuum, and I have discovered methods for interposing it in rapid succession in a current in a minimum space of time, depending upon the principle of making and breaking a current rapidly in a vacuum.

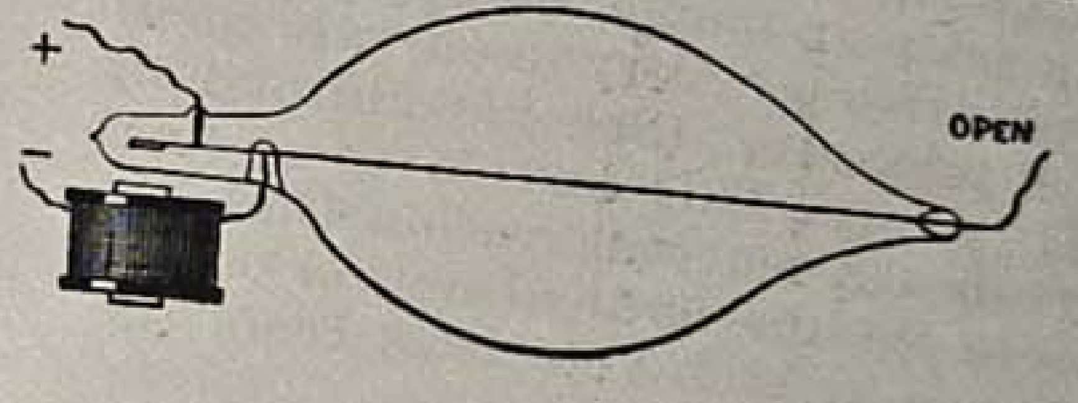

FIG. 4.

The disruption of any current in the air results in the formation of a spark of greater of less length, and the greater its length, the less sudden the break. Therefore, if the break be made in a vacuum, the narrowest conceivable complete gap in the metallic conductor results in an almost instantaneous discontinuance of current, insuring a maximum c. e. m. f. The current is thus interrupted in an almost infinitely short space of time as compared with all the ingenious mechanical contrivances, such as air-blasts and magnetic blow-outs devised for the purpose of breaking a current suddenly in the open air, but all of which are of little avail for the production of any quantity of light.

The vacuum vibrator, as shown in Fig. 2, is the nucleus of my invention. Although an exceedingly small device (not as large as one's finger) it demonstrates when in circuit with a small magnet (not as large as a teacup), a principle embodying great possibilities. It is a new piece of apparatus, exemplifying a principle of value not only applicable in practical use, but also an improved implement for scientific investigation.

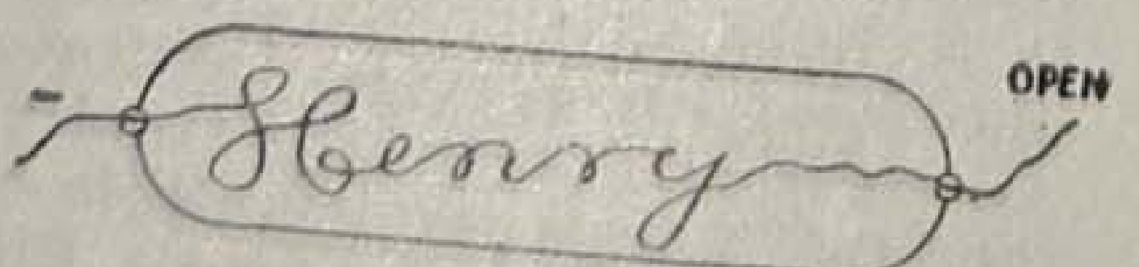

FIG. 5.

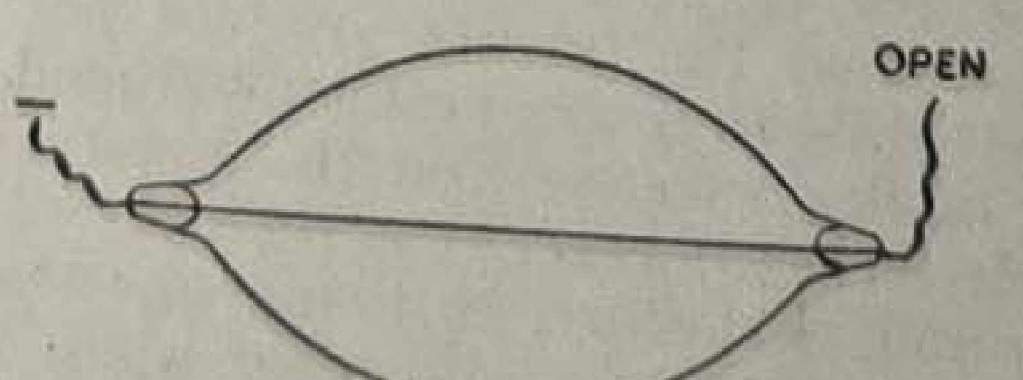

FIG. 6.

It is almost unnecessary to describe such a simple piece of apparatus, which consists merely of a spring rigidly supported at one end, and having attached to its free end a small disc of soft iron. A contact point rests against the spring at about its center. A sealed glass tube, from which the air is exhausted, incloses both spring and contact point. The system, as a whole, is exceedingly simple. An electric current passes through a coil of wire and then through the vacuum vibrator. Wires in contact with the outside of each of the ends of a closed and empty glass tube are attached to the two ends of the coil of wire. (Fig. 3.) This statement embodies the gist of the invention. It will be noticed that this system is far simpler than the apparatus ordinarily used to excite Geissler tubes. The secondary coil is absent, reducing the expense and bulk manyfold, as are also the metallic terminals sealed into the ends of the Geissler tube, but it produces light, the desideratum, in wonderfully increased volume.

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[1] Read at the meeting of the Am. Inst. Elec. Engrs. April 22, 1896.

With this apparatus, currents of almost any voltage can be rapidly and suddenly interrupted, and it is therefore now possible to obtain by using ordinary commercial currents, strong light in vacuum tubes.

When the circuit through the magnet and vibrator is closed, the armature within the vacuum vibrates rapidly, disrupting the current within the vacuum at each vibration.

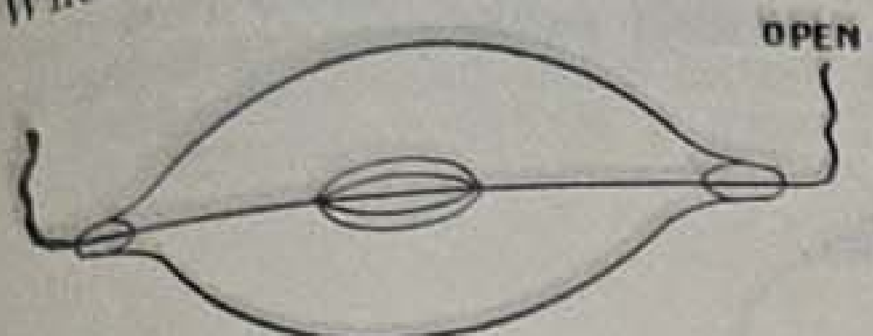


FIG. 7.

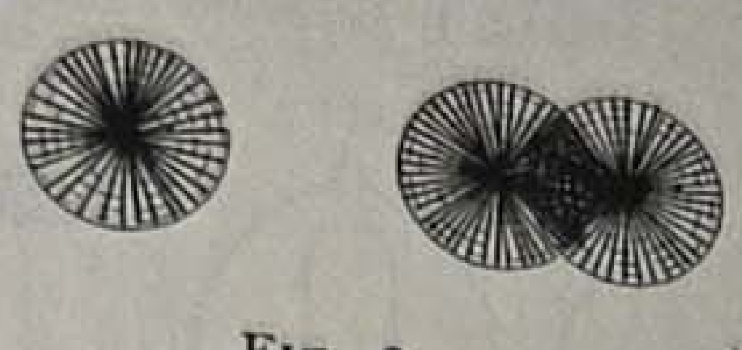


FIG. 8.

The resulting high tension current excites a brilliant luminosity in another tube, usually of much larger dimensions, and containing a lower vacuum than the vibrator tube. There is, therefore, a necessity for two vacuums, one the very highest, the other very low. However, I have tried a number of experiments, using but one vacuum, practically amounting to an enlargement of the vibrator tube and a lowering of its vacuum. (See Fig. 4.)

This is manifestly not a good plan for the production of light, because the breaking of the current does not occur in a high vacuum, but it led to an interesting line of experiments, the most novel of which will now be brought to your attention.

Within this low vacuum is placed a wire which can be bent and shaped into any form desired, as shown in Fig. 5. When connected to the vibrator, the beautiful effect is immediately apparent, the wire being enveloped in a delicate purple glow. This can be applied to various purposes, such as advertising. One wire only connects this sign tube to the vibrator, and it is attached to the armature terminal of the vibrator, because when so connected, it is the one which receives the high potential discharge of the magnet. In the bulb now shown (Fig. 6), the vacuum is higher, and a single wire extends through the center. The light, instead of appearing as a purple envelope around the wire, now fills the entire chamber with a beautiful milky glow.

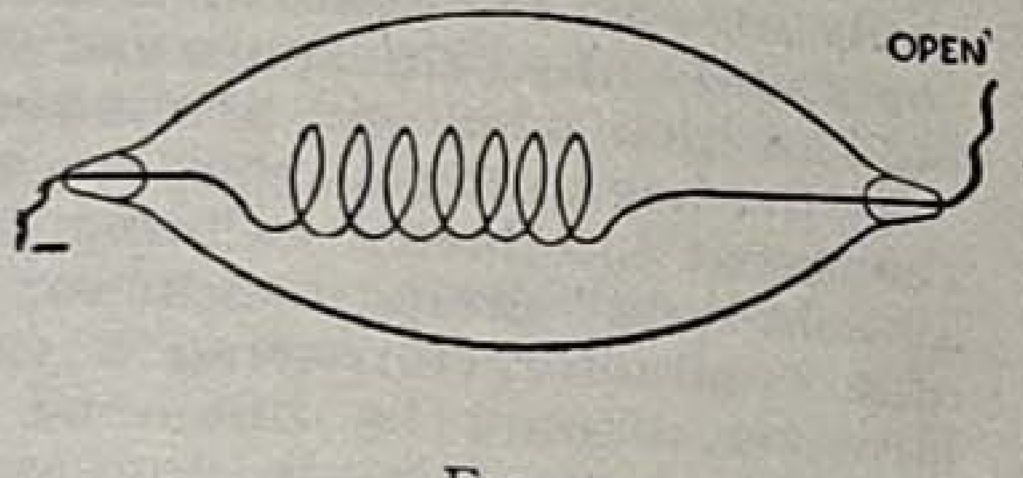


FIG. 9.

Close inspection, however, reveals the fact that there is a very small dark space immediately encircling the wire, and beyond it there appear to be rapidly moving rings of light, concentric with it. In fact, one is reminded of the field of force surrounding a conductor, as displayed by the familiar arrangement of iron filings—indeed, it is a similar phenomenon—the molecules of the residual gas taking the place of the iron filings.

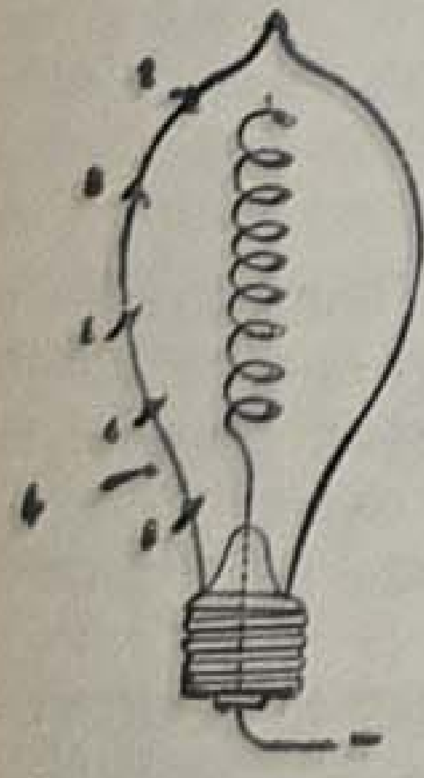


FIG. 11.

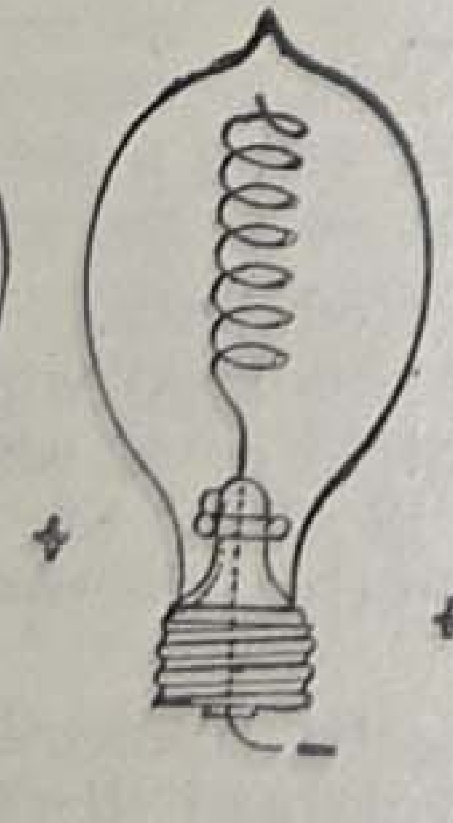


FIG. 12.

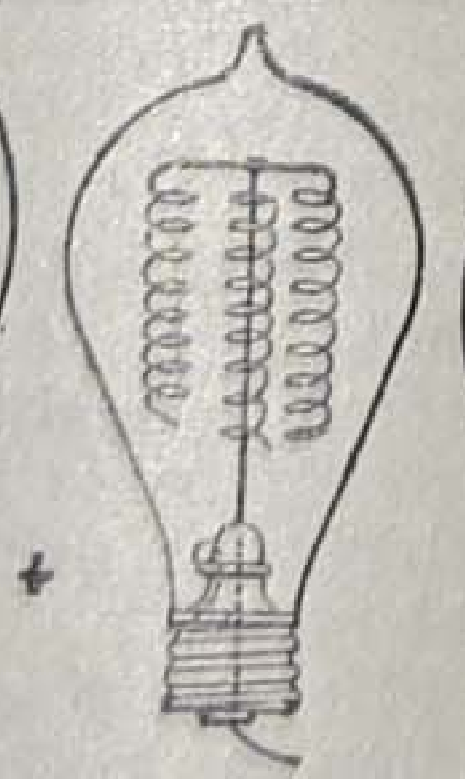


FIG. 13.

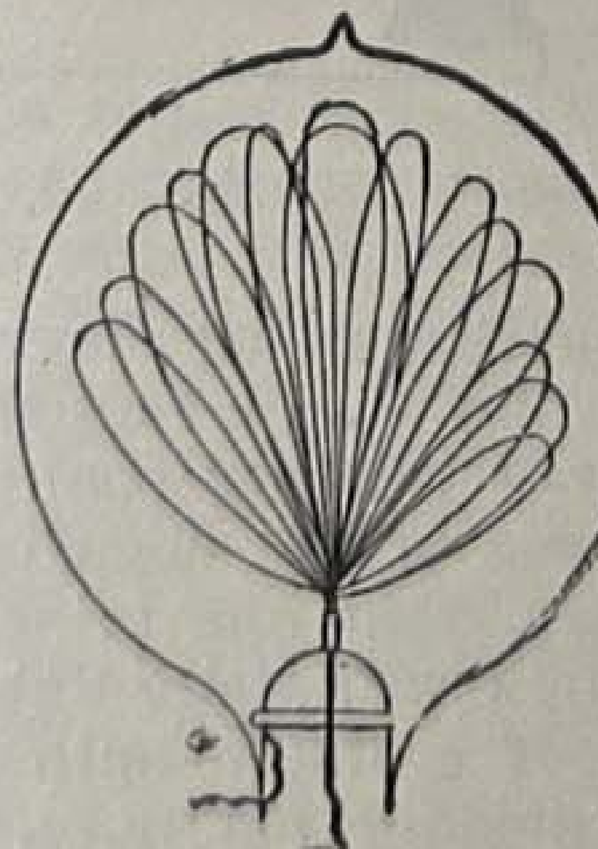


FIG. 14.

The next bulb (Fig. 7) is similar to the one last shown, but with one exception. The wire is not single throughout its entire length; for a space of about three inches at its center it separates into six strands, which thereby form a kind of cylindrical cage about one-half inch in diameter. In this case the entire bulb is not filled with a glow, but the interior of the cylinder forms a pencil of light quite dense, denoting that a new principle is brought into play. It is this—every current creates its own electrostatic field around its conductor, which, when immersed in a gas at the proper degree of rarefaction, causes it to give forth light, which is most dense in a comparatively small circle surrounding the conductor. (Fig. 8.)

When two wires, each having its field of force, are placed parallel to each other and about one-half inch apart, the density of the field between them will be doubled, and consequently the light in almost the same proportion. It will thus be clear that the pencil of light is due to the intersecting or overlapping of the fields of force of each of the six strands forming the cage. Upon this new principle many interesting lamps have been constructed, the problem being to get a maximum number of fields of force to intersect. Probably the best solution is in a cylinder made by spirally winding a wire, as in Fig. 9, causing its field to intersect in a manner that is almost ideal. This explanation may seem at variance with Faraday's famous experiment, proving that an electrostatic charge does not reside in the interior of the charged body. The vacuum may make the difference.

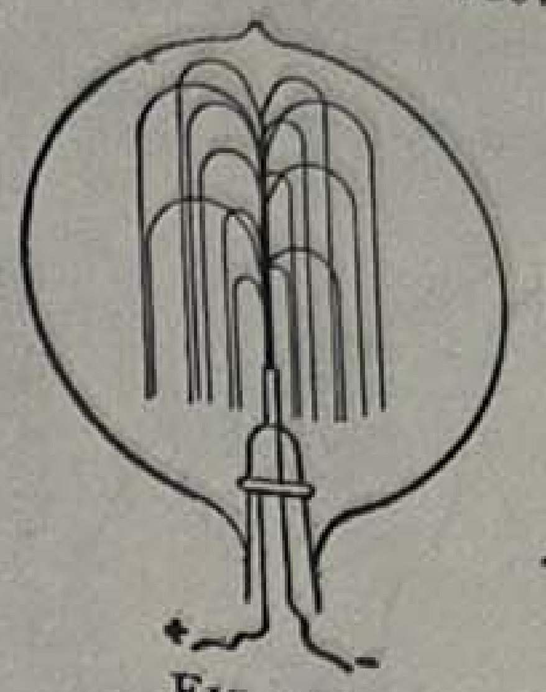


FIG. 15.

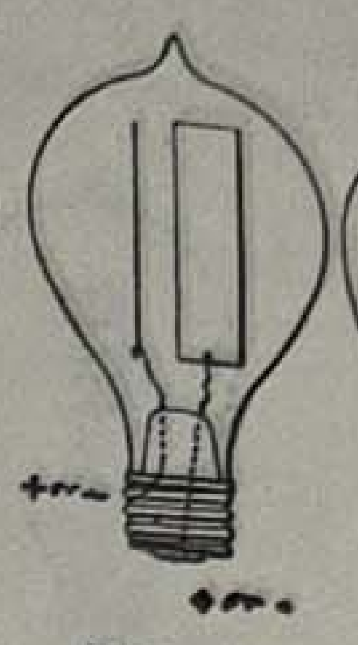


FIG. 16.

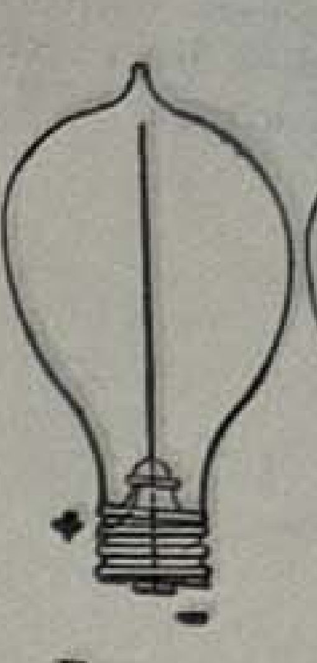


FIG. 17.

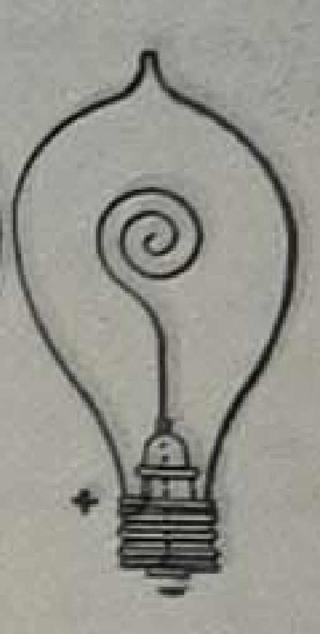


FIG. 18.

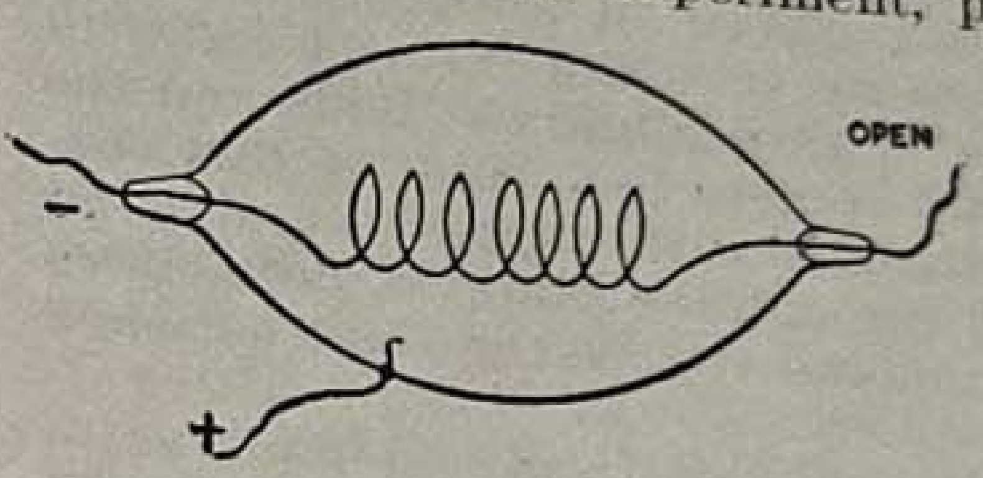


FIG. 10.

In this bulb (Fig. 10) there are two separate terminals projecting from the glass. When the spiral is connected to the negative pole of the vibrator, and the other terminal is made positive, the light is greatly increased. Such a lamp can be very conveniently made by using an incandescent lamp bulb, as in Fig. 11. The bit of platinum wire extending into the bulb and forming the positive pole, can be placed in any of the positions 1, 2, 3, 4, 5, without affecting the light in the spiral, but it is apt to become heated, and this is remedied by attaching to it a metal wire ring. (Fig. 12.)

In these lamps a large proportion of the light is confined within the spiral, and since volume is desirable, the idea of increasing the number of spirals suggests itself, as in Fig. 13. But the total volume of light emitted by four spirals is only equal to that of a single spiral lamp, that is, each pencil is but one-fourth as bright; hence, to bring them all to full brightness, the energy of the inductive current should be increased in proportion.

With the idea of obtaining from the entire bulb a uniform glow, the lamp shown in Fig. 14 was constructed. The "filament" consists of a great many complete loops of very fine aluminum wire. Fine wire was used, not only because of appearance and weight, but also for two other reasons: 1st, because a fine wire has about as large a field of force as a much larger wire; and, 2nd, because it does not obstruct the light so much, and at the same time is a minimum of metal within the vacuum. This is a matter of importance, as upon it largely depends the life of the lamp. A great many different conductors were used for the construction of these filaments, the main idea being to use that material which contained the least occluded gas, and would be disintegrated a minimum by the action of the current. Fig. 15 shows ordinary incandescent lamp filaments utilized in a glow lamp, but one leg only is cemented at the center of the bulb to the negative terminal, the other being free—a veritable fountain of filaments. A rather curious and not entirely explained phenomenon was noticed in this form of lamp, viz., the free ends of the filaments were apt to be violently agitated, and whenever they touched the glass of the bulb, they heated up to a bright red throughout their entire length, producing a most brilliant combination glow and incandescent light. Many are the advantages of these lamps over those using fluorescent materials, as the sulphide of zinc or calcium. Sometimes when the exhaustion is carried a little too far, the vibrator current is unable to affect the lamps, but after they are held in contact with one pole of a large induction coil for a few moments, and then connected to the vibrator current, the trouble ceases.

In all of these forms of lamps it is very interesting to note that in order to get maximum light, the sub-divided terminal of the lamp must be so connected to the mains that it is negative. This is interesting to remember when the subject of lighting tubes is considered.

The class of lamps will now be considered where, instead of sub-dividing the lighting electrode into filaments, plane surfaces are used.

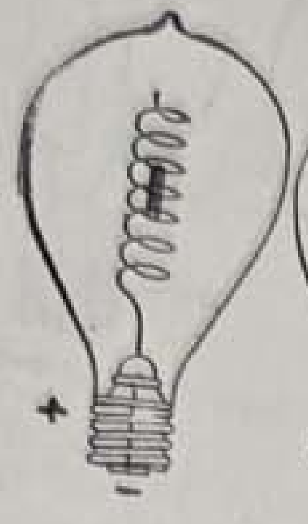


FIG. 19.

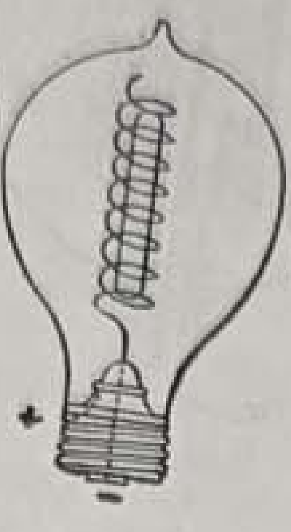


FIG. 20.

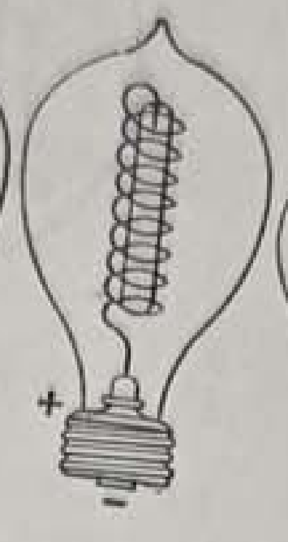


FIG. 21.

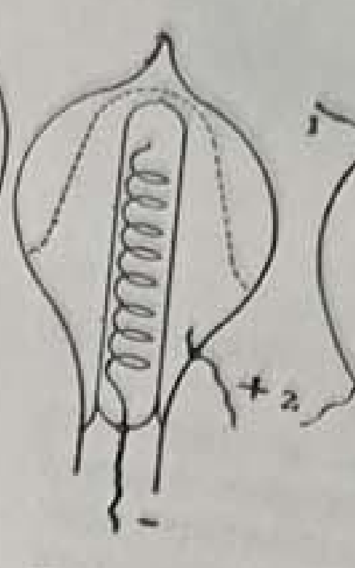


FIG. 22.

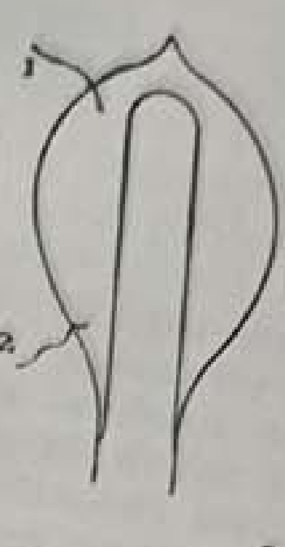


FIG. 23.

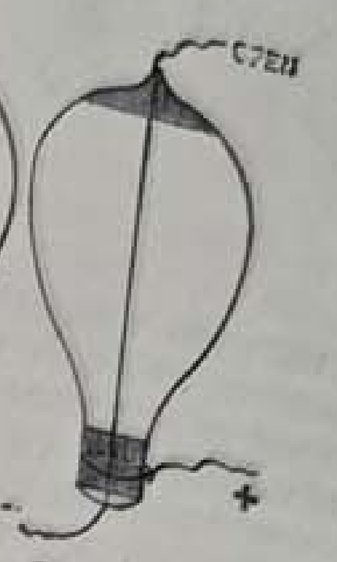


FIG. 24.

The bulb in Fig. 16 contains two pieces of sheet aluminum equal in size, set with their planes at right angles to each other, in order that a minimum of light may be interrupted from any point of view, and that the positive will act as a reflector to the negative. These pieces of aluminum must be carefully cleaned before being placed in the lamp, because any grease upon them will cause beautiful tufts of light all over their surfaces, instead of a glow filling the bulb, and the vacuum will soon be lost. Of course, in a lamp of this construction the poles can be changed with impunity, and if an alternating current be passed through the vibrator, both plates will give light, but the total amount will be the same as when direct current is used.

One of the many modifications of this form of lamp was to make the magnetic pole in the form of a small cylinder of aluminum gauze.

Many lamps were made on the principle of a spiral within a spiral, wound in the same or opposite directions, and also of using metallic coatings on the tube's interior and exterior, as well as using bulbs of all shapes and sizes. One important advantage to be noticed in all these forms of lamps is the total absence of the very objectionable striations, such as occur in the ordinary Geissler tube.

Fig. 17 is a very simple form of lamp—merely a single piece of straight carbon filament producing the light.

Fig. 18 is another of peculiar form—an unusual density of white light inside the convolutions of the spiral.

To determine whether there was any appreciable heat at the center of an intense pencil of light, a number of lamps were constructed in which various substances were placed at the point of greatest density of light, as in Fig. 19, but in no instance was the substance affected in any degree whatever.

Following out this idea a little further, there was inserted a small glass tube containing air properly rarefied in the center of a spiral, as in Fig. 20.

But the inside of the small tube remained dark; nevertheless, the glow outside of the spiral, dark space and other phenomena, even to the tufts of light between some of the convolutions of the spiral are the same as those in a similar lamp without a tube, inside the spiral.

Another lamp was then made the same as the last, except the tube inside the spiral has a platinum wire extending into it, which wire is electrically connected with the spiral (Fig. 21). Of course, the small tube was tried separately before being placed in the lamp bulb, and it filled with a white glow. But after the lamp was completed it refused to give any light; the glow outside the spiral, however, was the same as though there was no inner tube present.

Hoping to get a lamp with almost no metal in the light-producing vacuum, the lamp shown in Fig. 22 was constructed—the spiral is within a separate tube. When tried, a tuft of light appeared in the top and bottom of the small tube which was surrounded by a faint glow, the outlines of which are shown by the dotted line.

The next step was to do away with the inner vacuum and construct a bulb as shown in Fig. 23. When a spiral was inserted in the tube and connected to the negative pole, the positive being either 1 or 2, a dark space an eighth inch deep surrounds the tube, beyond which a faint pinkish glow appeared filling the bulb. The phenomenon known as "after-glow," which is sometimes noticed in evacuated bulbs after having been subjected to an electrostatic strain, I have been able to obtain, but very seldom. (Fig. 24.) However, this bulb could be picked up and carried around the room, but every time it was picked up after being laid down, a discharge resulted, which, being repeated three or four times, dissipated the glow entirely.

From a tube containing two parallel wires, shown in Fig. 25, but with a low degree of exhaustion, the glow was entirely absent, but instead brilliant, flaming yellow discharges completely filled the space between the wires, which was over half an inch wide and about two feet long.

At the beginning of the lecture your attention was called to the great similarity existing between the field of force of a "cold-light" giving conductor in a partial vacuum, and that of a conductor conveying a current in the open air. Care, however, should be taken to note that the light from the rarefied atmosphere is due to electrostatic and not electro-magnetic phenomena.

For example, I have here a powerful electro-magnet which I connect directly across the lighting mains and, therefore, it is one at whose center or core the electro-magnetic field is very dense. When this tube, which has a diameter the same as that of the core of the magnet, has about half of its length passed through the center of the magnet, no light whatever results. If, however, but one terminal (the other being free) of this same magnet be connected to the vibrator, immediately the tube gives forth light.

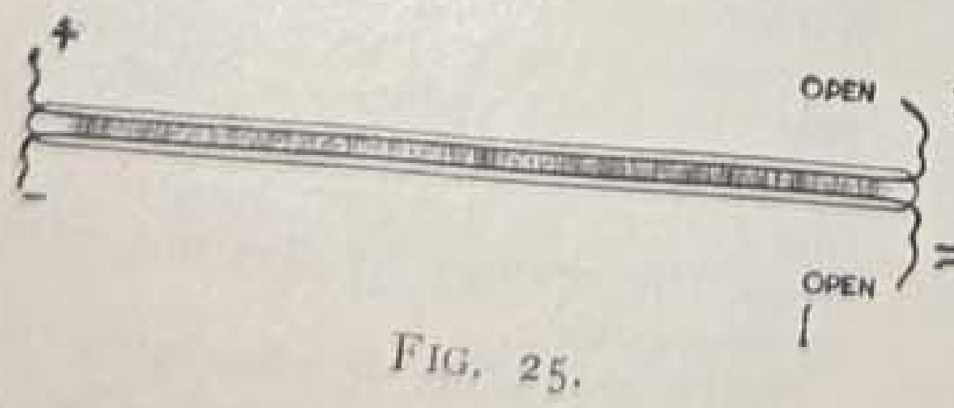


FIG. 25.

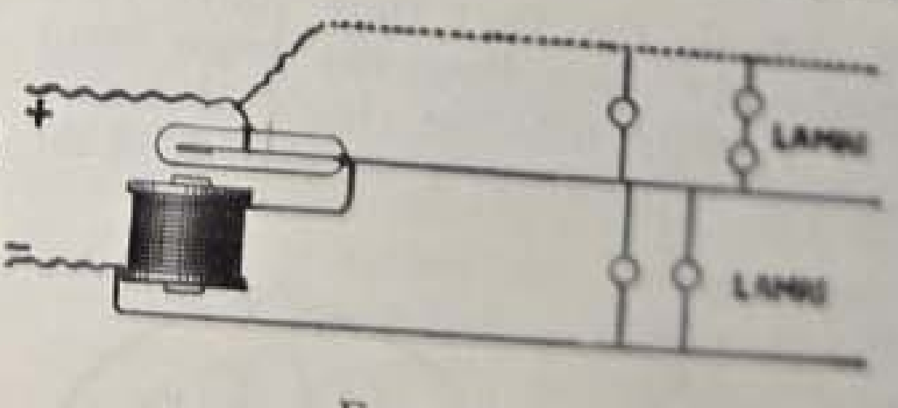


FIG. 26.

Referring again to the subject of connections, Fig. 26 shows the light connected around the terminals of the magnet; it also can be connected with equal results around the break or spark gap as shown by the dotted lines. Your attention is called to the fact that lamps of this kind will operate equally well whether connected in multiple or in series, provided the area of the negative electrode is about the same in each; if not, that one in which the negative electrode is of greatest area will alone light up.

If a single bulb of small size be connected to a circuit of considerable induction, a well-defined discharge is liable to occur which will ruin the lamp.

In Fig. 27 an inductive resistance is distributed with each lamp, making the system of distribution self-regulating, that is, the turning on or off of lamps will not affect the brilliancy of those burning steadily.

Referring again to the diagram of circuits showing the system in its simplest form: If good results are to be obtained, the magnet must be designed and constructed with the greatest care. Its duties are twofold; first, to give the vibrator its mechanical motion, and second, to act as an inductive resistance. The iron core must be proportioned to the conditions of the circuit. If there be too much or too little, the light suffers, but a certain amount of iron should remain, in order that the magnet have sufficient power to vibrate the armature. Similarly if there be too many or too few turns of wire on the magnet, the light is decreased. From this it is evident that vibrators of different rates will not be suitable to the same magnet. However, even when a vibrator is connected to a suitable magnet and circuit, and produces a good light, it can be further improved by "tuning the circuit," that is, altering its self-induction by varying the amount of iron in the magnet's core. It should also be stated that by this means a maximum light is obtained from a minimum current. In order that the time constant of the magnet be a minimum, and to insure rapid action, the magnets should be short and thick. Large induction coils cause the tubes or lamps to give forth but little light, while a small magnet, whose length of wire is not one-hundredth that of the induction coil, will cause the tubes and lamps to light up brilliantly.

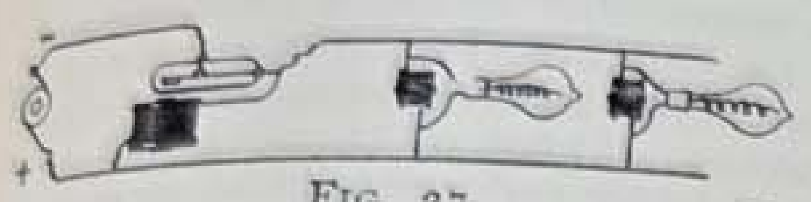


Fig. 27.

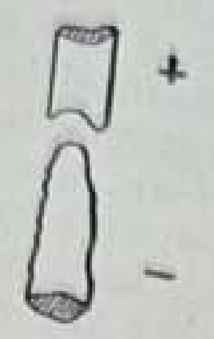
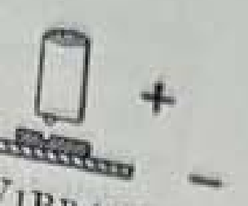


Fig. 28.—Electric Light Carbon.



Vibrator Contact Points.

It is interesting to note that with a comparatively few turns of wire a very small one-volt battery will give quite a strong glow. This glow can be intensified by using a secondary coil.

Although the various lamps that have been described are of great interest, nevertheless the very nature of lighting by luminescent gas is such that it is far more applicable to radiate from sources of considerable area than from units of light of small area. The best method of obtaining light from a large area is by the utilization of tubes of considerable length, instead of small bulbs. The light of these tubes should be entirely free from the very objectionable striations always present when interior electrodes are used; but these striations are entirely obviated by using exterior electrodes. They may be metal caps on the outside of the tube, or preferably merely coatings of metallic paint. Such tubes can be made up in almost any lengths, and can be bent into a great variety of forms, making them suitable for exquisite decorative effects.

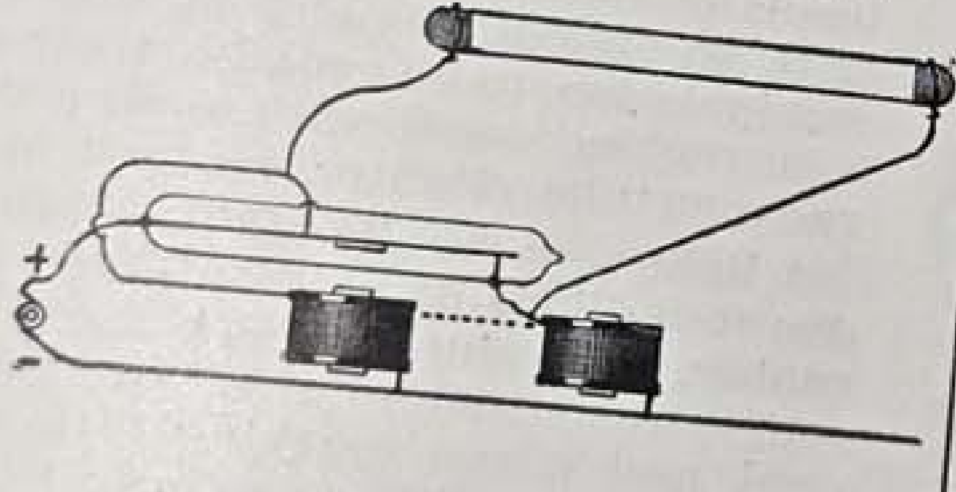


Fig. 29.

Under this head can be mentioned the fashioning of tubes in the form of letters, which may be used as electric signs.

Permit me to call your attention once more to the key of the whole system, viz., repeated interruptions of an electric current in a high vacuum.

The simplest method of accomplishing this object is to hermetically seal within a glass tube a vibrator of ordinary form, but its exact construction to give the best results has been a matter of tedious experimentation and study. The very slightest alteration in the dimensions of almost any of its parts—such as the length, width and thickness of the spring, or its method of mounting, or the position of the contact points, or the thickness or diameter of the armature, will cause it to be a very good or a very poor vibrator. Again, the operations of the glass-blower had to be watched most carefully. Only certain kinds of iron and steel were selected, to avoid occluded gases, and even then they must undergo a special treatment before being fit for use. The selection of suitable contact points has also been a large field for research. Nearly all known conducting substances have been tried, and many interesting facts have developed in this connection, not only so far as the direct action of the various metals in vacuo and various gases is concerned [illegible] is the reverse of the phenomenon [illegible], but also with reference to the electro deposition or electrolytic action that takes place. For instance, as [illegible], the positive electrode is the one which disintegrates most rapidly in the open air, and its apex is usually concave. This is probably best shown in the ordinary direct current arc lamps. If aluminum or any soft metal of comparatively low fusing point be used as contacts in a vibrator, after about a day's run, an examination shows that the shape and condition of the contacts are just the reverse of the way they appear after use in the open air. That is, the positive terminal looks like the negative, and the negative like the positive. (See Fig. 28.)

I have constructed several dozen distinct varieties or amplifications of the ordinary type of vibrator, such as multiple contacts, etc.

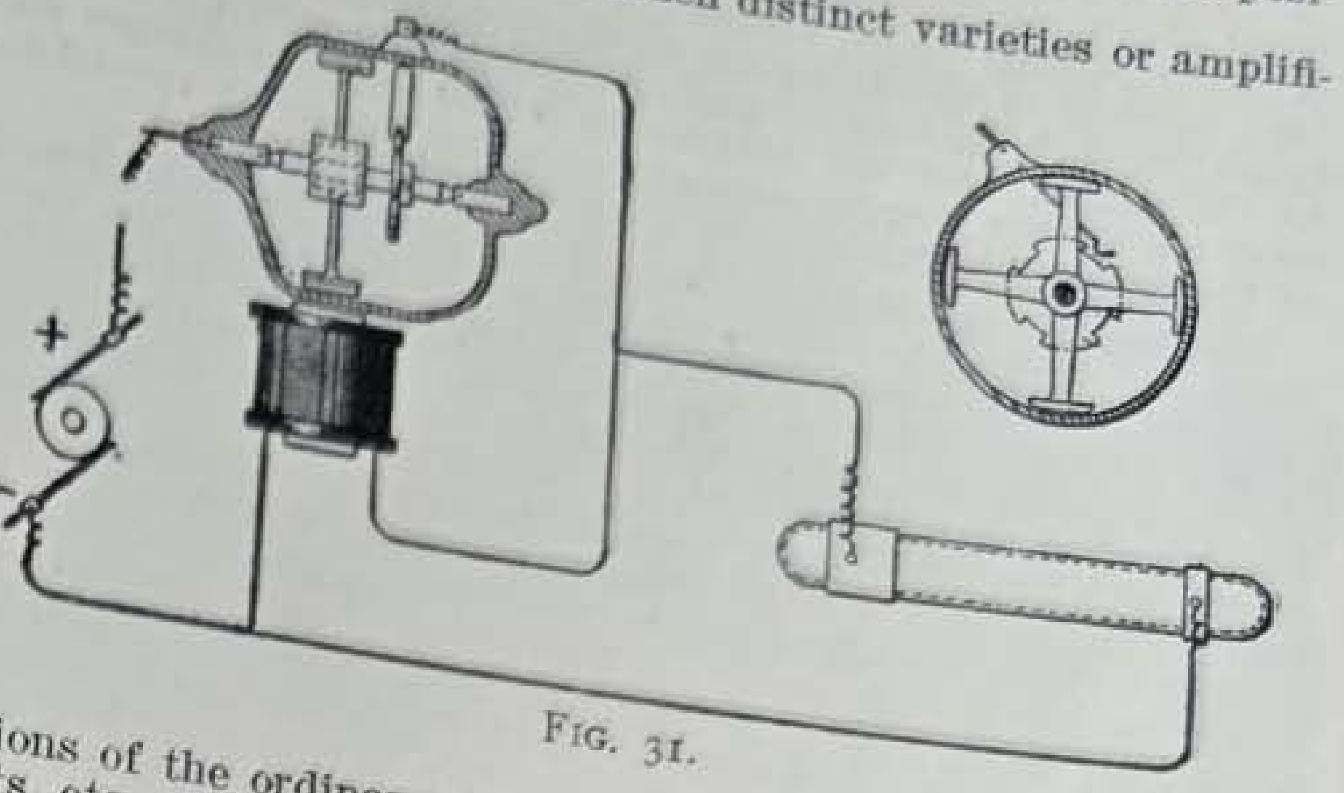


Fig. 31.

Fig. 29 shows one form, in which the object was to produce a larger number of breaks of the current per unit of time by providing two contacts, as shown. In some respects this scheme worked well, that is, the light was stronger than that produced by an ordinary vibrator with a single magnet, but the light was not steady, and when the connections were changed so that but one magnet was used, the light flickered still more. All the vibrators, so far considered, have had their springs so adjusted that the contacts remained normally closed. Fig. 30 shows a circuit using a vibrator normally open. The small magnet constantly closes the circuit and the large one opens it. This arrangement gave a good light. A number of ordinary vibrators have been operated, arranged with the magnet above the armature, so that gravity helps close the circuit. Of course, springs and armatures of scores of shapes and sizes, including gravity vibrators, have been tried, the principal object being to obtain a method for taking up the wear of the contact points; but the best solution of this problem lay in getting contact points that would not wear because of a more perfect vacuum.

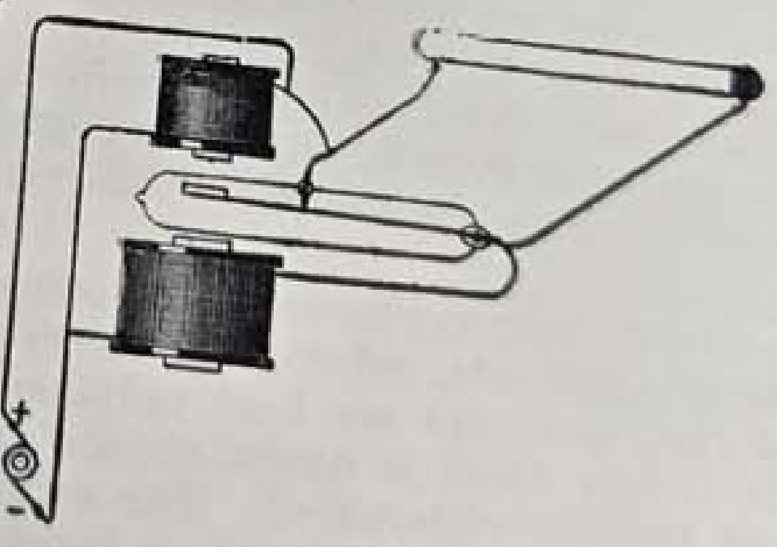


Fig. 30.

Turning now from the mechanical construction of vacuum vibrators to consideration of their unique properties from a scientific standpoint. As stated before, roughly speaking, the prime object of making the break of the current in a vacuum is to produce an increased c. e. m. f. over that resulting from an airbreak. But I venture to say, few as yet realize the possibilities and the tremendous advantages involved in the separation of electrodes in high vacua at regular periods of time. It is indeed questionable whether the increased c. e. m. f. of the ether gap is responsible for the results. It is more probably due to the fact that the wave-lengths of the current resulting from an ether gap differ radically from any that have heretofore been known of. Recognition of the importance of this phenomenon led me to use the word "etheric" in connection with my system of tube lighting, because the light is directly dependent upon what I designate as the ether gap of the vacuum. Our best notion of the separate existence of the ether is formed by thinking of that which remains within a vacuum of the highest degree we can produce. It may have been noticed, that so far I have not used the word "phosphorescent." It is undoubtedly a misnomer as applied to tube lighting; but to make matters worse, there seems to be no word in existence exactly or even approximately suitable.

The word etheric is especially applicable to light produced by the ether gap. That incomparably better results should be obtained by using a vacuum as a dielectric seems to be in perfect accord with accepted theory which has largely been upheld by actual experimentation. For example, setting aside for the time being that part taken by the magnet, let us consider only the break—the spark.

First, what is required is a continuance of the rapid oscillations of an electric discharge, and I desire to show that this is accomplished by a vacuum vibrator in an ideal manner. One method of obtaining an oscillating discharge is to use a potential such that an air-gap of considerable width is bridged by the spark. But the manner in which such discharges succeed each other largely depends upon the irregular movement of the air within the gap.

This method is unsatisfactory for many other reasons, among them the very objectionable high tension required, but there remains the conductive method of causing a spark, exemplified in the ordinary vibrator and induction coil. Here the sparks in the primary circuit can be made to succeed each other quite rapidly, but the length of time required for each complete break is long. However, with the vacuum vibrator, a new and simple device, the conditions are different and so are the results. Here the dielectric is an exceedingly thin film of ether, which is capable of withstanding a great electrostatic strain, but when it does break down it does so very suddenly; that is, it may be considered a perfectly disruptive discharge, and therefore its single oscillations are very short; but as a whole they are long continued. This means that the frequency is high, and, according to Maxwell, very high frequency oscillations are probably identical with light.

The small magnet, being a circuit of induction, has its own natural period. But its period and moment of inertia will be less the less its capacity. That is, the smaller the magnet the smaller the period, or the higher its frequency can be.

But to have an intense light, there is required a high e. m. f. of self-induction. This the small magnet furnishes, because what is lost in self-induction by using a comparatively few turns of wire is more than made up by the suddenness of the discontinuance of current flow, and the fact that the high vacuum precludes the possibility of loss to the self-induction ordinarily due to the glow discharge which precedes the disruptive discharge in the air. The self-induction also depends on the amount of current flowing through a circuit when interrupted, and this the vibrator provides for, in that all the current which flows through the coil does not pass through an arc, but is transmitted over actual metal contacts. Also since these contacts are so very close, due to the thinness of the dielectric, the oscillatory discharges do not leave the metal and pass in objectionable minute streams through the vacuum. And the number of oscillations in the coil and the amount of light, depend in a measure on energy expended to overcome the resistance of the dielectric which is almost infinitely greater than that of air.

That the silent discharge prevents long continuance of oscillation is shown in the Hertz experiments, where the experiment fails unless the balls of the electrodes are kept polished. That the vacuum vibrator is nearly ideal is again shown in that these troubles are almost entirely eliminated. The ether is undoubtedly the ideal medium in which to disrupt an inductive circuit for conversion into light; since an exceedingly thin film (if this term may be so used) is a dielectric of such strength that a very small displacement results when it is disrupted, and the ether being the medium of minimum rigidity closes the "hole" the instant it is pierced. Such a medium for such a purpose is almost incomparable to air or oil, which becomes volatilized.

In order to get any oscillations, more sudden rushes of current must occur on discharging than on charging, and the more nearly these equal each other, the quicker the rushes will succeed each other. Now, in the case in question, when the tube circuit with its condenser coatings has a certain capacity, the self-induction of the magnet can be so varied that these two will always neutralize each other, and then the critical strain on the dielectric requires but little energy to cause a discharge, and the circuit being almost balanced, the surges follow each other in rapid succession through the tube. The surges continue for a longer time, since the energy of the discharge is not dissipated in heat on the air, but is conserved to be utilized in prolonging the existence of the oscillations. The use of this vibrator seems to afford the best means yet invented for impressing molecular disturbances in a tube. The longer the oscillations exist, the more nearly the mean oscillation approaches a constant period, and this period is practically governable as compared with that of currents due to magnetic blasts or heated air currents. The higher the frequency, the greater the mean free paths of the molecules, because a less number of molecules will then be required to cause a given number of collisions, and the less the number of impacts, the greater will be the light in proportion to the heat. But the frequency is dependent on the capacity of the condenser, which, in the case of the tube coatings, is very small.

When the self-induction and capacity are properly proportioned, and the rate of the vibrator is the same as the natural period of the coil, or any of its harmonics, then there is resonance, and the maximum amplitude of each impulse will be constant. In this case the current flow is at its maximum, but so also is the voltage at the ends of the tube, as well as the quantity of light produced with a minimum expenditure of energy. The velocity of the lines of force produced by an oscillatory discharge is supposed to be equal to that of light, but its wave-lengths are exceedingly greater. But this disparity is greatly reduced by the vacuum vibrator. This accounts for the intense light in the tube at comparatively low potentials, and indicates that nature's keyboard has been struck to the tune of 500 trillions of waves per second, and that this rate is maintained by the fundamental mechanical vibrations of the vibrator—about 100 per second—a most beautiful demonstration of nature's wonderful compass. But not only is more light produced by the vacuum vibrator than was heretofore obtainable, but there accompany it many other advantages of particular importance. Three of these can be mentioned: first, simplicity and greatly reduced cost of apparatus; second, the obviation of impracticable potential, and third, a very marked advance in economical production. The first heading, simplicity, has already been dwelt upon. Compare an inexpensive magnet, not as large as one's hand, and a vibrator the size of one's finger, attached to commercial currents, with apparatus costing thousands of dollars, consisting of a high speed alternating dynamo of many coils, oil transformers, disruptive discarges with magnetic blast, induction coils and condensers. The many seemingly unsurmountable difficulties encountered with this method are almost completely overcome by the simple expedient of the ether gap. Or, referring to ordinary induction coils, the vacuum break affords a means for obtaining from the few turns of comparatively coarse wire results not obtainable with mammoth and expensive coils made of many miles of wire, and capable of creating enormous differences of potential.

The second heading is essentially a practical one. It has often been argued, to the detriment of tube lighting, that since it was admitted by its supporters that enormously high potentials were absolutely requisite to cause any appreciable amount of light, that therefore (and the argument was logical) the whole idea was extremely impracticable unless some new insulator be discovered that could cope with the high potentials, so difficult, dangerous and expensive of generation and manipulation, as to prohibit their use commercially. But with a current endowed with such properties as are given it by a vacuum tube vibrator, no new insulator is needed.

A light now results many times brighter than that formerly due to millions of volts, able to pierce several inches of hard rubber, or produce a spark many inches in length, from a current transmitted to the bulb or tube over ordinary flexible cord, and whose sparking distance is less than one-sixteenth of an inch. Neither can any shock be felt from such a current. Another example of the comparative ease with which this new current can be insulated is apparent in the magnets, wound in the ordinary manner, in striking contrast with the necessity for expensive and cumbersome oil transformers. In this light the exclusion of all gaseous matter does not seem to be a matter of such vital importance.

Closely allied with the subject of insulation is that of frequency. The higher the frequency, the lower the potential can be, not only with respect to light, but also to insulation, because irregularity in the rate of vibration puts the insulation to a severe test. However, the period of the vibrator is not rapid as compared to that of alternating dynamos, constructed to obtain similar lighting effects, but resulting in those of lesser degree. The alternations of such a machine are about 30,000 per second, which is further increased by a disruptive discharge coil. This was necessary to compensate for the long wave-lengths of the current. But since these lengths are so much shorter in the vacuum vibrator current, an initial frequency one-fifth as great without the use of additional coils and condensers produces far better results. But that an ordinarily constructed vibrator can attain a speed of 6,000 per minute may be questioned, when it is remembered that induction coil vibrators work at a rate of but little over 1,000. The difference lies in the fact that the vacuum vibrator has no air pressure to impede its movements, and also that a much shorter space of time is required for a single complete interruption, because the actual mechanical movement can be much less, yet cause a complete break, and another cycle has begun. The speed of the vibrators is ascertained in two ways: first, by comparing the musical note it produces with that of a pitch pipe, and secondly, by a visual arrangement constructed and operated as follows:

A shaft, supporting a wheel with one spoke, is rotated rapidly by hand, a series of multiplying gears being used, so that when the hand makes one revolution per second, the spoke makes twenty. When this apparatus is operated in a room, lighted only by a single vacuum tube, the spoke will appear stationary in one, two or three positions, according to the rate of the vibrator. For example, if the spoke appears stationary in two positions, it indicates that it is illuminated twice in a single revolution, each image being due to a vibration.

Another subject, which has been a serious obstacle in former proposed systems, is that of impedance. The fact that the best conductors would cease to transmit current seemed a difficulty almost unsurmountable; yet it appears to be almost absent under these new conditions. For example, when a large coil is inserted in the high potential lead from the armature terminal to the tube, the effect on the light is surprisingly small. The result is the same, whether the wire be in the form of a magnet or in a long exposed line. But, nevertheless, on account of line losses, it is advantageous to prevent condenser action by using a wire as small as possible, yet able to stand the strain it is subjected to when its insulation is being placed upon it. Although the light produced by a single wire is quite good, it is decidedly advisable for best results to use a return wire, because the fundamental frequency is so low.

The third subject—economy—is so large, and of such importance that I deem it expedient to make it the subject of a future paper when accurate measurements have been made. Indeed, it is second only—but it is second—to the nucleus of the whole investigation, viz., getting light. The efficiency of the lighting tube is well established, due principally to the great amount of light accompanied by so little heat that it has by some been called "cold" light. The temperature of the gas within the tube varies with the density of the discharge from 12° to 132° C.; but even this is improved by the shorter wave-lengths. These figures are extremely low as compared with temperatures as high as 3,500° C., which must be reached by some substances in order that the light be white and the spectrum complete.

Owing to the peculiar characteristics of the current, the line losses are materially decreased, and the current flowing through the primary circuit is less when the tube is giving light than when it is disconnected. There are almost no losses for motive power to disrupt the current, for the magnet is its own motor. But the greatest loss has always been in the disruptive discharge—the spark. It is remarkable how easily several horse-power can be dissipated in the air through the intervention of a disruptive discharge. In this connection it should be borne in mind that magnetic blow-outs and air currents are merely heat dissipaters, and increase the loss, while these losses are entirely obviated by the vacuum vibrator. The current can perform a large amount of work on the air, unlimited in volume, with no apparent results; but when this volume is reduced to the campass of a small vibrator tube which remains perfectly cool in operation, does not the question of efficiency assume a different aspect?

Upon these reasons may be based logical conclusions, pointing to an enormous increase in efficiency over that of all other methods of obaining light in tubes.

The theory which has just been considered, of course, is not limited to a simple vibrator, but applies broadly to any method of interrupting the flow of current through a high vacuum. This can be accomplished in a great variety of ways, although as far as simplicity of apparatus is concerned, the regular spring vibrator, in connection with a single magnet, probably cannot be improved upon.

The first deviation, however, is to use a very small magnet to vibrate the armature, and to connect this in series with a larger one to furnish the induction. But in these cases the power of the operating magnet depends on the current passing over the contact points; hence to make the light which is dependent on the contact points perfectly positive, the power should not be dependent upon them, and separate circuits suggest themselves—that is, cause an intermittent current to flow through the power magnet that does not flow through the contact points of the vibrator, which have in circuit with them the inductive magnet. Or the electrodes can be separated by mechanical jarring instead of magnetic power acting through the glass.

If an ordinarily constructed vibrator be attached to any form of rapidly oscillating mechanism, the contacts within will be opened and closed rapidly. But in order that the light be steady, the movements of the vibrator armature must be in step with the movements of its mechanical support. This is best accomplished by having the center of the oscillation of the vibrating armature coincident with that of its oscillating support.

It is plain that it is unnecessary that the current be interrupted by a reciprocal motion only; a rotary motion is also applicable.

Fig. 31 shows a form somewhat analogous in operation to the simplest vibrator, except that the rotary momentum of the armature takes the place of a spring, and the break-wheel which furnishes the light also acts as a commutator to the simple form of motor.

Another way of obtaining a rotary motion within a vacuum is to attach a pendant weight to a ratchet wheel, free to rotate upon a shaft attached to which is the brush. Since the shaft is rigidly sealed into the glass, it is evident that when the bulb be rotated by a motor, the brush will revolve around the break wheel. The fault with the device is that the pendulum will have a vibration of its own, causing the light to waver.

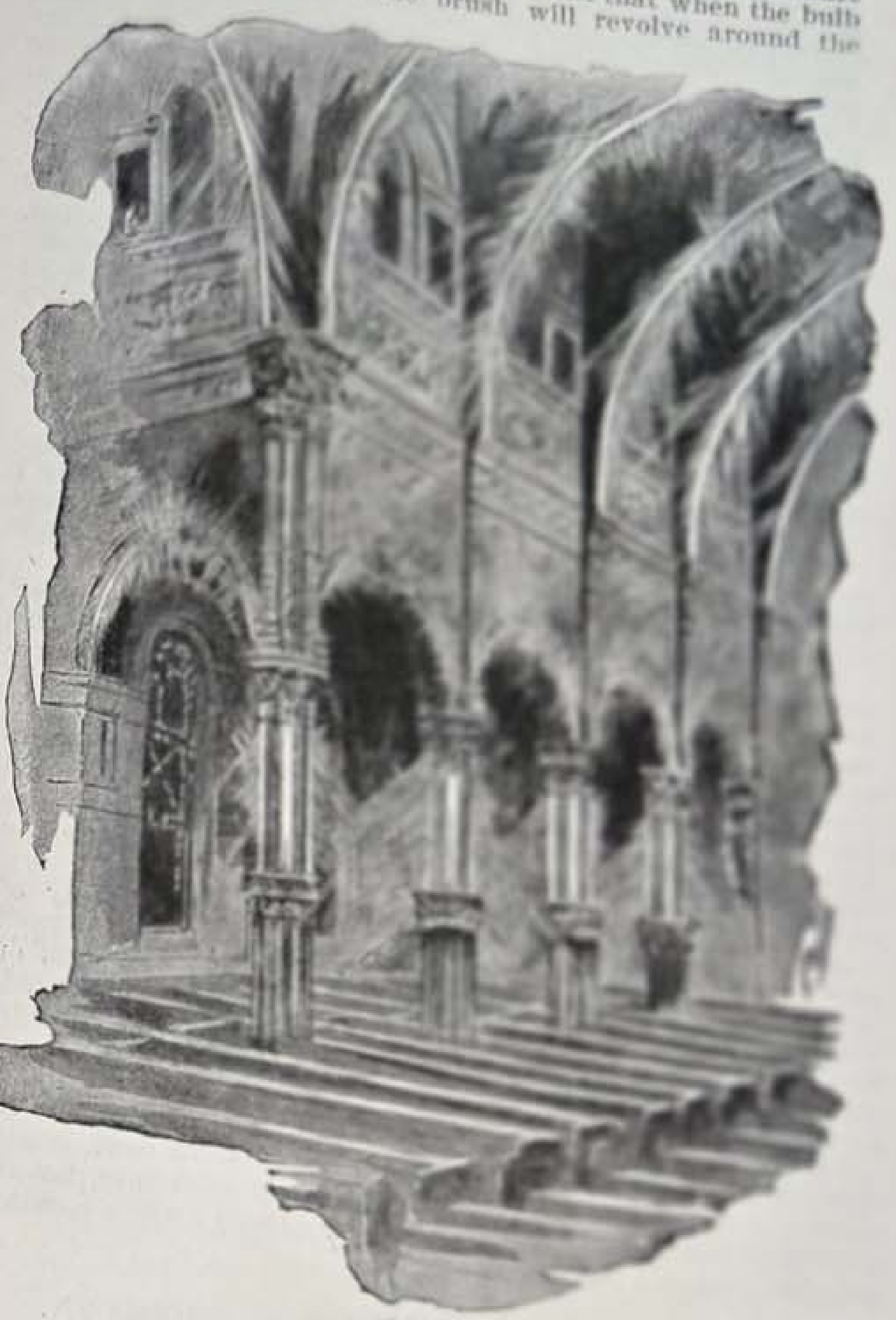


Fig. 32.

In order that the make-and-break devices dependent upon a rotary motion be absolutely positive, a rotating magnetic field has been utilized. Since the experimental side of these investigations has extended over but a few months, it is at present difficult to say upon which of these methods, developed, the system will take final form.

Returning once more to the subject of the light in the tube. It is interesting to note, that although the most intense light is produced when both of the ends of the tube are connected to the electrodes, it is well known that light also results when the tube is merely placed near an electrode without actual contact. This phenomenon is known as lighting by induction.

If an inductive circuit, sufficiently powerful to brilliantly illuminate a tube four feet long, be transformed to one two feet long, there will appear at the center of this small tube a very intense thread of silvery white light, which undulates as if it were a material substance. It is interesting to contrast the color of the light of these tubes with that of an incandescent lamp. The reddish and wasteful glare of the latter, indicating heat waves, and the pure daylight white of the former, are immediately apparent. It is this difference in color that makes an efficiency calculation so difficult. It is very easy to ask the question: How many watts per candle power? But in most instances it indicates a lack of information on the part of the questioner. The question should be: How many watts per amount of light equivalent to one candle-power? But even this is not perfectly correct, because it is wellnigh impossible to compare accurately lights of a different color and power of diffusion. When the use the light is to be put to is stated, the problem is much more simple. For instance, if it is to be used to read by, the range of legibility can be made the basis of comparison between the true glow lamp and the candle. This most popular form of illumination, from the twelfth to the beginning of this century, is still the standard of illumination, though it is probable it will soon be deprived of this honor. I owe an apology for calling your attention to the remarkable efficiency of the light in these tubes, in connection with the assertion repeatedly made by eminent scientists, that such light was an impossibility, and that efforts in this direction were comparable to those wasted on perpetual motion. The ideal source of the light, if it is to be counterpart of the daylight, is such that when a square inch of the surface of the tube gives as much light as that thrown into a room through an aperture one inch square, the want is satisfied. And the highest illumination can be reached by multiplying the size and length of the tubes, and distributing them in the most advantageous manner, that is, so that the light will fall from all directions. When a considerable area is to be lighted, the most efficient light is the one that is most equally distributed. However, there will always be a demand for units of light, that can be satisfied by using a tube of small size. The lamp is made by winding a small tube in the form of a spiral, the ends, to which the wires are attached, projecting in strong bulbs three or four times the diameter of the small tube.

I have previously stated that the alphabet has been constructed of tubes of light. Here are the initials of the body I have the honor to address, A. I. E. E., in letters twelve inches high. The intense shades of these letters cannot fail to elicit admiration from all who love the beautiful.

The principle of breaking a circuit in a vacuum has many applications in a variety of uses. Among them may be mentioned advertising signs, decorative electric lighting, electro-photographic apparatus, theatrical effects, in the [illegible] of images in the kinetoscope, etc., etc.

But the greatest work will ultimately be that of general illumination. You have noticed the tubes extending around this hall. Undoubtedly this is the first time that lighting by tubes has been attempted on so large a scale. You will note the soft, gentle glow, absence of shadows.

Now, to summarize what we are coming to in the way of electric lighting. For some time past everything has pointed to the general adoption sooner or later of some such form of illumination, and when volumes of light can now be produced, and of commercial intensity, does it not indicate that already this light is a matter for serious practical consideration, and no longer a perfunctory curiosity?

But the only way in which one can form a comprehensive or appreciative idea of what advance in this line of work really means, is to compare the situation of to-day with that, not of [illegible] years ago only, but with that of only twelve months ago, and note the contrast.

ELECTRIC LIGHTING CONTRACTS IN BROOKLYN.

The Brooklyn aldermen approved of these public electric lighting contracts:

Edison Electric Light Company, 35 cents per light of 1,200 candle power a night, and 17½ cents for lights of 600 candle power.

Municipal Electric Light Company, arc lights of 1,200 candle power 34 cents, and for incandescent lights 16 cents per 1,000 watts meter measure.

Citizens' Electric Light Company, for lighting public buildings, 2.2 cents per lamp hour. For street lighting, 35 cents per light, 1,200 candle power.

There are now 2,250 lights in use, and they will soon be increased by a thousand. It is claimed that the city will save $35,000 by this year's contracts.

THE ELECTRIC CIGAR LIGHTING AND ADVERTISING COMPANY, of St. Louis, has been formed by M. J. Stern, F. Werner, and C. B. McCormack, with a capital stock of $20,000.

THE BLOCK LIGHTING AND POWER COMPANY, with offices at the Grand Hotel, proposes to increase its capital stock from $50,000 to $100,000.

THE OHIO STATE SENATE has passed the Jones bill inflicting the electrical method of punishment in death sentences, and it is expected that the House will concur.

KNOXVILLE, TENN.—The new electric light plant about to be installed by the Brookside Cotton Mills, Knoxville, Tenn., will consist of General Electric Company dynamo and a [illegible] engine of the Ball Engine Company (Erie, Pa.) manufacture.

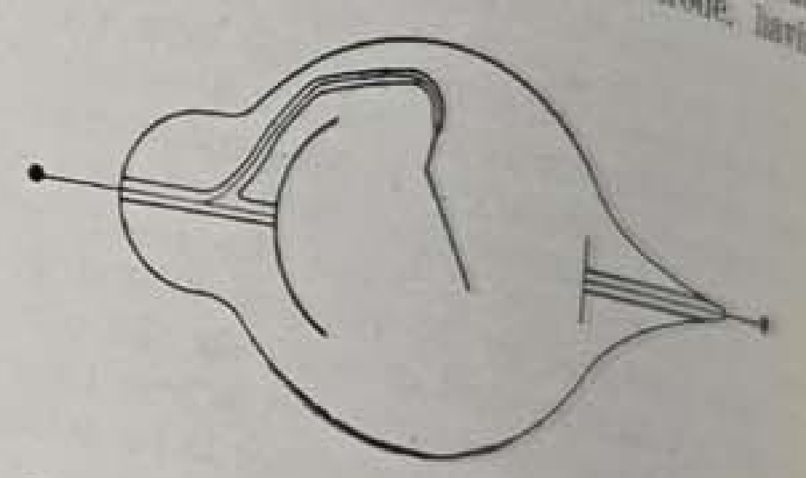
FURTHER PROGRESS IN RADIOGRAPHY.[1]

BY DR. OLIVER J. LODGE.

I HAVE been several times forced to surmise that just as the original Lenard rays are easily stopped by a few inches of air and have feeble penetrating power, so Röntgen rays may be of two or more kinds, perhaps differing in something of the fashion that violet light differs from red; and that, whereas close to the source we get Röntgen and Lenard rays mixed, and a little further off Röntgen rays only, i. e., those which discriminate most clearly and throw therefore the most instructive shadows, so after great obstruction, like a human body, only the most penetrating quality of ray gets through. And under these circumstances the interposition of the palm of one's hand scarcely adds to the shadow, nor do the bones of the palm make their appearance in so prominent a manner as one might expect from the general brightness. Against this, however, is to be recorded the fact that I have taken a photograph of a spine to discover the nature of the damage to a vertebra in a patient, and the details of the processes of the vertebræ.

When the cathode rays do not first strike the glass, but first strike a piece of metal inclosed in the bulb, then its behavior depends largely on what it is connected to. My experiments on this point are not complete, but this much is certain, that if the bombarded piece of metal is attached to the cathode, so that it is unable to receive any electrical charges from the cathode stream, then it either declines to act as a source of rays at all, or else emits a radiation of the most feeble kind, which can without difficulty be attributed to a secondary cause. But on the other hand, if the bombarded disc be connected to the anode, so as to be able to receive the negative charges of the cathode stream, then it acts as a most vigorous source. In a low state of vacuum it will indeed get hot and radiate light, but in a high vacuum every part of the bulb keeps perfectly cool, and the whole energy supplied seems to pass off in X-rays.

The following experiment is worth quoting at greater length. A bulb like this, with concave electrode, having at its



center a rather thick aluminum plate connected to it metallicly (wires protected by glass), and beyond in its shadow the other electrode, was excited either with the cup as cathode or with the cup as anode, and pinhole photographs were taken simultaneously from various points of view, and at measured distances. A glass plate was subsequently put in the position of each of the sensitive plates, and the appearance of the tube as seen through the "pinholes" (which were one-quarter inch diameter), by an eye roving about, were drawn in ink upon the glass. The eye-picture thus obtained was afterward compared with the developed images, and the sources of the radiation thus clearly observed.

When the small flat disc was cathode, every part of the complicated anode appeared strongly and quickly on the plate, especially the tilted and first bombarded portion on a plate placed above the tube. The cathode disc itself did not show at all. On a plate placed below the bulb the anode cup appeared strong, but the tilted disc did not appear. On the other hand it threw a sharp faint shadow of the hole, showing that its focus spot acted as a feeble point source, by reason of a few rays reflected back onto it from the cup.

When the current was reversed, the small disc anode showed faintly, being excited by rays which had penetrated the interposed tilted disc, but again the cathode hardly showed at all, not even the tilted portion on a plate placed below the bulb. By giving a very long exposure (two hours) some impression was obtained, about equal to that from the shaded anode disc; but, of course, if the tilted plate had been under these circumstance an anode, it is well known that a few minutes would have sufficed to show it strong upon the plate beneath.

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[1] Abstract from the London "Electrician."

ed no more energy than the twenty-five incandescent ps with which the Institute auditorium is regularly ghted!

To be exact, each of the twenty-seven tubes, which were n. 4 ins. long, by 1¾ ins. in diameter, took one-eighth of an pere at 450 volts, as measured by recently standardized tion instruments; that is, a fraction over 56 watts per be, or a total of two horse-power for the entire number!

We abhor sensationalism, but cannot resist the expression ur belief that this result, once its import is fully grasped, l influence powerfully future work in this direction. Mr. ore's system of vacuum tube lighting is still open to provements in some of its details, but enough has been wn to demonstrate its immediate utility for a number of ful commercial purposes. It can only be a question of when all its features—including the character of the t, which to some appears too garish, like that of a Welsbach burner—will have been brought into conformity with the ands of the public. As to its economy, that point seems well disposed of, so that it remains now only to reduce apparatus and adapt the light to a commercial basis, and the simplicity of the apparatus employed this ought to be plished in a short space of time. If vacuum tube lighte not the direction to work in, we would like to be med what is.

GENERAL ELECTRIC OUTLOOK.

t week The Electrical Engineer was able by its enter- present its readers with the General Electric Company's l report, although several of its esteemed contemporaries ver a word about it and others had but a brief reference. port is always one of the leading events of the year, rthy, therefore, of the effort we made to put it promptly the electrical public.

e took occasion to note last week, the General Electric y would appear on its own showing to be worth about nts on the dollar. A concern which with liabilities of 45,000,000 writes off $13,917,000 to profit and loss, ppear to be in need of reorganization of some kind, in personnel, but certainly in its financial basis. If pany were alone in the field or enjoyed monopolies, it ecover from such losses, as other concerns often do, o not believe that a single well informed person in the field expects to see that done. On the contrary, with tide of competition sweeping away much of its business with the tendency to specialization making many of roducts rapidly out of date or second class, it would , in spite of the financial skill of a high order that the evidently has at command, it must submit to the t of its capital as a permanent condition.

the fact that the huge capital is based on an monopoly which never did and never will exist, it ognized as one of the conditions of the times, that umber of the local companies are quickly drifting h and sympathy with the company. They complain , ill treatment, and high prices, and are beginning ly outside the company's factories, or to be more ctly interested in rival undertakings. In 1894, the the old Edison local companies was very warlike ning; and if there has been any change since then he worse, we have failed to note it in our inquires ations.

's report, as President, notes the "patent deal" estinghouse Company. We fear that Mr. Coffin is ll the truth. It doesn't make much difference to at the deal is, but when such papers as the ia Record" go so far as to talk of the "business is clear that the real facts are leaking out. Our sion is that a straight out pooling on business that the percentage alleged to apply to the y applies to the amount of sales. In fact, we do not see how anybody but a subtle mathematician, crossbred between a Steinmetz and a Pupin, could work out a "patent" percentage; whereas a rate of division on sales, with sliding give and take, is the easiest thing in the world to work out and to play on the stock market. If our surmise be correct, then Mr. Westinghouse has got the better of his dear friend Mr. Coffin, to a most appreciable degree. But then Mr. Westinghouse as a lamb was never greatly inclined to lie down with the lion—on the inside of that noble animal.

THE X-RAY SOUND WAVE THEORY.

THE theory put forward by Mr. Edison to account for the Röntgen ray phenomenon, namely, that it is a high-pitch sound wave, has not met with general acceptance, and this is scarcely to be wondered at, considering the strong preconceived notions of physicists on the nature of cathode rays and their effects. But in looking over the phenomena recently brought to light by many experimenters in connection with the Röntgen ray, it strikes us that we may have to considerably alter our views regarding the transmission of sound waves through a vacuum. It is an accepted fact in physics that sound will not travel through a vacuum, and when we have reached the highest attainable exhaustion, light then passes through, transmitted by the ether. According to mathematical deductions from the kinetic theory of gases, Schuster's accepted explanation of the working of the Crookes radiometer and the condensation of carbonic acid gas upon glass, as shown by Bottomley, J. J. Thomson, and Bunsen, together with the known presence of mercury vapor, our highest attainable vacuum still contains billions of molecules, and it is still conceivable that if a sound wave in air of small wave length strike the outside of the glass tube, it would be transmitted across the vacuous space not in the manner usually assumed—by rarefaction and condensation—but by bombardment or impact of the residual molecules thrown by the elastic wave in the glass across the bulb. Hence the fact that a vacuum does not stop the X-ray except, as we understand, to weaken it; but, Mr. Edison contends, this cannot be used as a positive proof that the ray is not a sound wave, and he is still searching for facts in further confirmation of his theory.

We note from a cable dispatch in the New York "Sun" that Professor Röntgen has published several important new discoveries connected with the X-rays. He has ascertained that all solid bodies can generate them under the influence of cathode rays, the only difference being as regards intensity. The most intense are produced by platina. He further says that the insertion of the Tesla spark gap break apparatus between the ray-producing apparatus and the Ruhmkorff apparatus is highly advantageous. He has made several experiments which confirm his observation that X-rays can discharge electric bodies, and that air illuminated by the rays can do the same. He further declares that electric bodies surrounded not by air, but by hydrogen or by highly rarefied air, are also discharged by the rays, though much more slowly.

THE ELECTRICAL EXPOSITION.

IT is now officially announced that the National Electrical Exposition will be opened with all appropriate formalities by Governor Levi P. Morton, of New York, at 8 p. m. on May 4. The occasion is likely to be one of great brilliance and interest, and we understand that every effort will be made to render it memorable. The last national electrical exposition, that at Philadelphia in 1884, was opened by Governor Robert Pattison, of Pennsylvania.

The pressure for space at the exposition has been so great that the exhibits have now overflowed to the third floor, of which a large part will be occupied as an annex by the Patent Office exhibit, the Edison Fluoroscope exhibit, and the Practical Electrical Laboratory, together with a number of commercial exhibitors.

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TICES IN OHIO.

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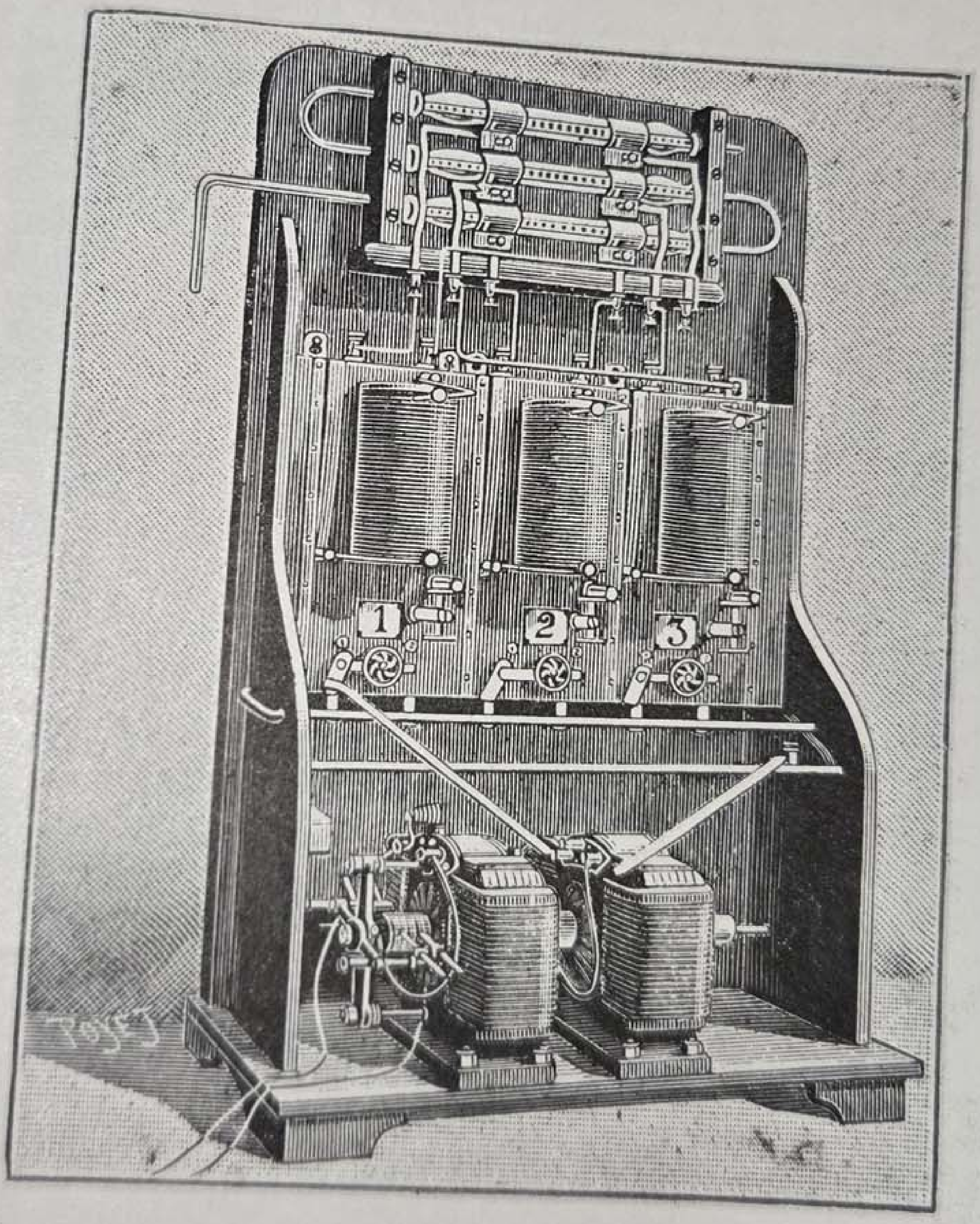
notifying the users of the
truments which are an in-
is taken as a warning that

MISCELLANEOUS.

OZONE GENERATOR OPERATED BY ELECTRIC MOTOR.

THE value of ozone in medicine, the bleaching of tissues, the rectification and artificial aging of wines, and the sterilization of water, air, etc., are well known, but the apparatus usually employed for that purpose is quite cumbersome. M. G. Séguy, after studying and operating a number of models, has arrived at the type of ozone generator illustrated in the accompanying illustration, taken from "La Nature."

On the upper part of a vertical board is mounted the tubular generator proper, consisting of three glass cylinders connected to one another, so as to effect a complete circulation, and leaving the two ends free or open. Each of these cylinders incloses a core of seven tubes, surrounded inside and outside by aluminum helices. The current derived from the machine to be described below traverses all these tubes, one pole being connected to the external helices, and the other pole to the internal. Consequently the current to complete the circuit has to pass through the glass, during which operation there are formed myriads of small sparks. This system of helices, consisting of 2,400 turns, has the power of considerably increasing the production of ozone.



THE SEGUY OZONE GENERATOR.

The air is taken in by the bent tube shown at the upper left-hand corner, passes successively through the three tubes, and comes out at the other end, after being transformed into supersaturated ozone.

The electric current is furnished by the three secondary circuits of the induction coils, marked 1, 2 and 3, which give 30,000 volts. The primary circuits of these are fed by a small dynamo, placed at the left side at the bottom of the case. This machine furnishes a potential of from six to eight volts, and fifteen to eighteen amperes. The dynamo is driven by a motor mounted on the same shaft, the motor being connected to the city distribution circuits. By this arrangement it is possibl

Company, of 1303 Monadnock Block, of the Bullard transformer, have been by the belief that many plants the most economical converter obtainable, the slight existing difference in first cost. that they will readily demonstrate, by for service test, that a net saving of thousand watt converter capacity can be the Bullard converter over the highest upon the market.

exhaustive test, made by Prof. H. S. Car- of Michigan, on a twenty light or 1,000 below:

	Regulation.	
cent.		Per cent.
[illegible]	Full load	2.52
[illegible]	¾ "	2
[illegible]	½ "	1.27
[illegible]		

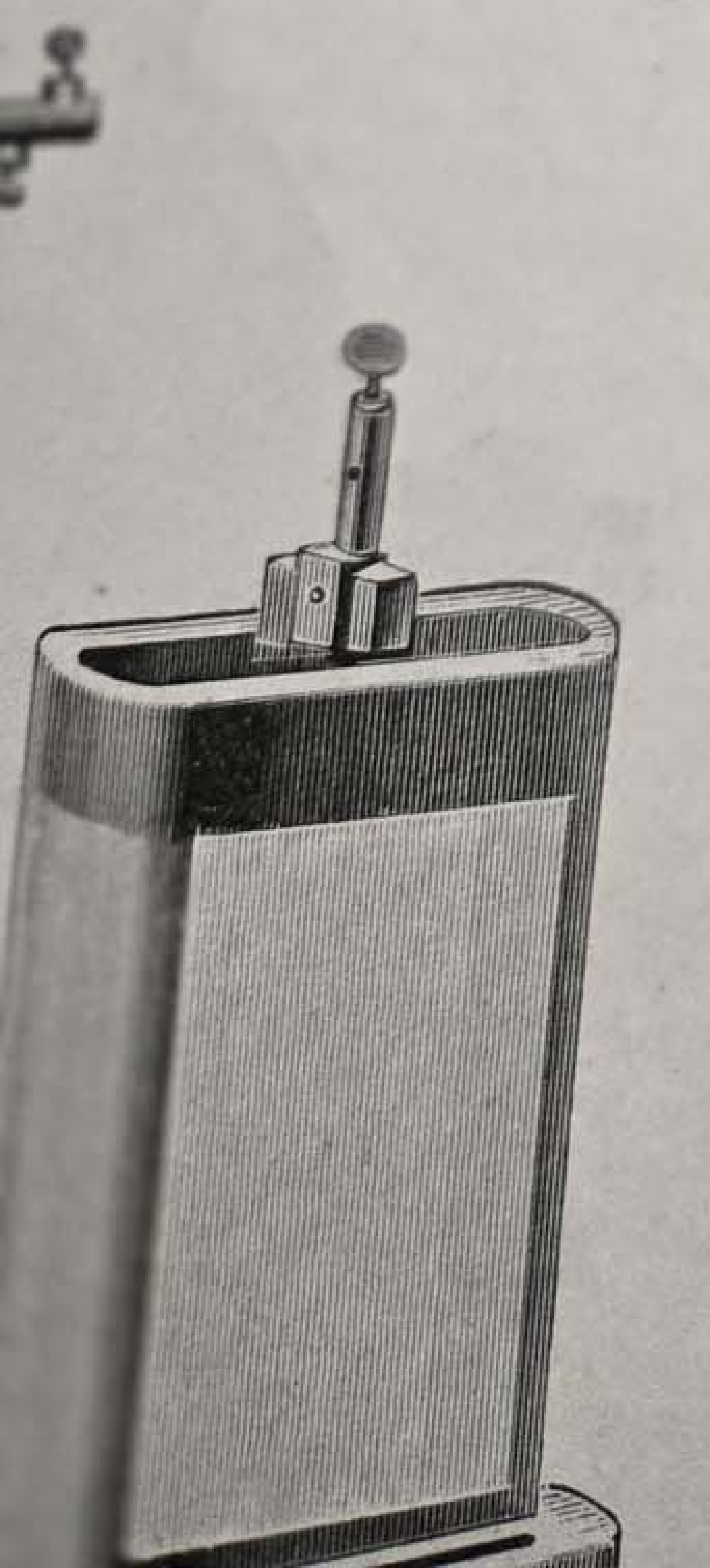
condaries: 23.6. Rise in temperature with full load: 21 deg. F. The larger rtionately better.

sformers are made with the greatest n being employed. Before finally thoroughly saturated and boiled in a insulating qualities, and are then being subjected for several days to transformers are made either for y, as may be desired, and for two

mer in case ready for installation. cross arms are packed with each ay be expeditiously installed on ral arrangement of the coil, ready A desirable feature of this trans- ot in any way bolted or screwed ent being such that the bolting oil in a firm and rigid position. made with detached fuse box, as box attached to the case of the so many difficulties in replacing ing obsolete.

K BATTERY.

represents the new Wheelock Messrs. J. H. Bunnell & Com- possesses the great advantage acity of 100 ampere-hours. It peculiar construction of the the strong depolarizing char-



for continuous closed circuit work and can be left on open circuit for as long a period as two months.

AN ALUMINUM FLUOROSCOPE.

BY J. A. LE ROY.

Accidents have led to many discoveries, and a little accident caused me to investigate and bring about the following result: While preparing a fluorescent screen, a small amount of the solution which I used to secure the crystals of tungstate of calcium spilled upon a sheet of tin, upon which it was customary for me to place the cardboard and apply the tungstate. While applying the same to the cardboard the moist spot on the tin plate became coated also. Desiring to know what effect the Röntgen rays would have upon metal coated with tungstate of calcium, I prepared screens made of various metals and coated them with crystals. I compared the metal screens with the ordinary cardboard screens and found that the aluminum screen gave better results; the outline and articulation of the bones of the hand stood out in bold relief and detail. The aluminum being more porous to the rays, evidently allowed them to penetrate to a greater degree than the cardboard. While testing the fluoroscopes, I excited a phosphorescent screen by means of an ignited magnesium tape. After the tape ceased burning, I found, on looking at the phosphorescent screen, fluorescence was caused upon both the cardboard and the aluminum fluoroscope. It was fairly visible in the former; in the second very intense. Now, the question presents itself, Is there an element of the X-rays in phosphorescent substances, and to what degree may they be employed advantageously?

I wish to acknowledge here many courtesies received from Dr. W. J. Morton in placing at my disposal his powerful X-ray apparatus.

PROF. ELIHU THOMSON ON THE FLUOROSCOPE.

Messrs. Aylsworth & Jackson, of Orange, N. J., makers of the Edison tungstate of calcium fluoroscope, have received the following letter from Prof. Elihu Thomson:

"Gentlemen: I tested your fluoroscope last night, and find it to be a magnificent piece of apparatus. I cannot say too much in praise of it, and, so far as I can judge, your claims as to the efficiency of tungstate of calcium in relation to barium platino-cyanide, are fully borne out in the use of the instrument.

"You are at liberty to use this letter in any way that you may desire, as I feel that it will only be conferring a benefit upon investigators, physicians and others to have at their disposal such an efficient means for examinations by Röntgen rays.

"I will certainly take pleasure in recommending the screen to any one who may desire to use such an instrument."

NEWS CLIPPINGS OF THE EXPOSITION.

The Newspaper Clippings Bureau, 1104-5 Bennett Building, this city, makes in our issue this week the offer to furnish a full set of clippings relative to the exposition, and all that is done there, for the strikingly modest sum of $10. It is also willing for a small sum to include a scrap book and assist in arranging it. We recommend all our friends and readers who want a valuable and interesting memento of the whole occasion to accept the proposition, right now. Nothing is more difficult than to get together such material after the event. In fact, it is impossible to do such a thing; but while the show is going on the Bureau, by its facilities, can get the matter together for immediate delivery or to be held as a collection for the subscriber. The idea is admirable, and the work of the Bureau is such as to enable us to recommend its offer for acceptance.

NEW ADDRESS OF THE OKONITE CO.

The old quarters of the Okonite Company, Limited, in Park Row, are soon to disappear before the march of events, and the

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THE
Electrical Engineer.
Vol. XXI. MARCH 18, 1896. No. 411.

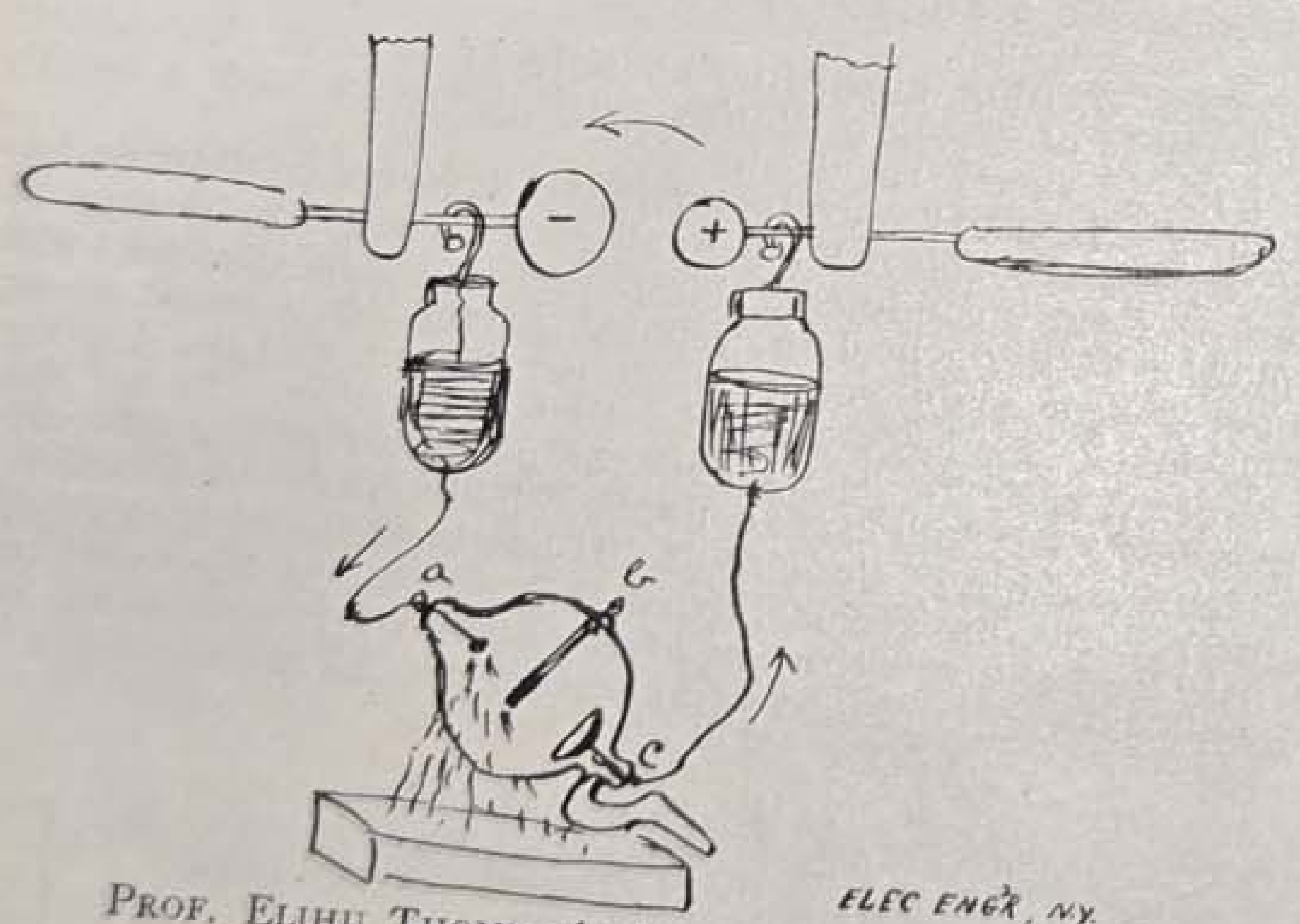
ELECTRIC LIGHTING.

ROENTGEN RAYS FROM THE ANODE TERMINAL.

Elihu Thomson

IN a recent note published in your journal concerning some experiments I made in tracing the Röntgen rays to their source at the metal terminal within the Crookes tube, from which they proceeded in straight lines, this terminal was spoken of as the cathode. I find that Professor Rowland has recently made some experiments which would point to its being the anode which evolves the rays, and on going over the polarities of the Wimshurst machine which I used in my experiments and the direction of the discharges I find that the terminal is indeed the anode from which the rays emanate.

There can be no question about it in the tube which I have used. Before reading Professor Rowland's observations I had been led to doubt its being the cathode which gave the rays and had, in fact, noticed that the terminal on the negative side of the Wimshurst machine is the one which gives the rays. During the discharge of the jars, however, this is not the cathode, but really the anode. These observations of Professor Rowland confirmed by my own would seem to at least point to the fact that the rays are not the same as what are called cathode rays, but that the Röntgen rays are, properly, anode rays.



PROF. ELIHU THOMSON'S ROENTGEN RAY TUBE.

I have used a fluorescent screen of barium platino-cyanide enclosed within a dark tube with a sight hole at one end, and I find that by having a patch of metal on the side of the Crookes tube, as soon as this metal piece comes between the anode and the screen all fluorescence of the screen ceases, but the slightest displacement either way produces fluorescence on the border of the screen.

This observation shows without doubt that the rays proceed in straight lines from the terminal within the tube, which turns out to be the anode. Experimenting with the Wimshurst machine enables one to be quite positive as to the direction of flow, while with a Ruhmkorff the tendency to oscillatory currents may disturb the observations, and, of course, with high frequency apparatus the anode and cathode are rapidly interchanged.

I enclose a sketch of the arrangement which I have used. I have found that one of the tubes I have is particularly active, and its history is, briefly, this: It was a tube having an aluminum cap as terminal c, an iluminum disc as terminal a, and between the two a platinum sheet mounted on a stem at the side of the bulb, b. It was used on high frequency currents, terminal c being left disconnected for fear of melting down the platinum piece by concentration of the cathode rays or radiant matter of Crookes thereon. During the use the vacuum gradually improved and finally the tube became insulating so that a three-inch spark would not send any discharge through the vacuum. At the same time, the terminal a, or aluminum disc, was melted down into a confused mass. The improvement of the vacuum was doubtless due to the carriage of metallic platinum from terminal b to the sides of the bulb, which absorbed the residual gas. It remained in this condition for a few days.

It was then decided to heat the tube for the purpose, if possible, of driving out the gas which had been taken up by the platinum deposited on the sides of the bulb. This was carefully done, and it was found that the tube became conducting once more and remained so. It, indeed, became, apparently, just in the right condition of exhaustion to give the best results.

I have endeavored to get Röntgen pictures with other Crookes tubes, but none have appeared so satisfactory as this one, and some which are apparently all right for exhibition of the Crookes phenomena give no Röntgen rays. I think it would be desirable in constructing such tubes to seal in a small flat or slightly convex surface of aluminum as an anode and a somewhat extended cathode disc of aluminum, and a third terminal of sheet platinum for the sole purpose of adjusting the vacuum, as by the use of the third terminal, with discharges passing therefrom such an amount of platinum may be deposited on the glass as will carry the vacuum up to the desired point, which is just short of that which makes the vacuum insulating in character.

MR. EDISON'S RESEARCHES ON ROENTGEN RAYS.

BY E. J. HOUSTON AND A. E. KENNELLY.

MR. THOMAS A. EDISON, after numerous experiments on Röntgen rays with about 150 different glass vacuum tubes, has communicated the following information to us for publication:

1. There is no apparent advantage in obtaining very high vacua in the Crookes tubes employed for photographing the shadows of metal gratings. The effect of a very high vacuum is to require a greater voltage to produce fluorescence. The best degree of vacuum is that at which the internal luminescence or striae in the tube just disappears and fluorescence of the walls remains. The Röntgen rays are still produced even when internal striae are observed but are enfeebled.

2. Thin walls are preferable to thick walls in the glass vacuum tubes. A thick wall will fluoresce very brilliantly and become very hot. A thin wall will emit rays having greater photographic power, but may scarcely fluoresce visibly, and will remain very cool. This is proved by a number of experiments, of which the following is one: A tube of the shape roughly indicated in the sketch, Fig. 1, has its walls blown thick in the zone of A C, but thin at B. When this tube is exhausted and excited, the thin part B, which is in the most actively excited area, remains cool and photographically very active, while the glass becomes hot in the ring A C. If B be made thick and A C thin, the glass at B may become melted by the heat, but its photographic power is reduced, although its visible fluorescence is greater. Walls ⅛ inch thick become unmanageable by excessive heat and rapid melting.

3. For any given tube in a given condition of exhaustion, the photographic power of the tube; i. e., the swiftness with which it produces a developable image is roughly proportional to the square of the fluorescent candle-power or total visible fluorescent light given out by the tube.

6. The duration of exposure has been found to be as follows: With the most sensitive plates in an ordinary plate holder having a light vulcanized fiber cover of about 1-32 inch thickness, the time necessary for obtaining a good shadowgraph of a metal grating or grid is less than one second, when the tube

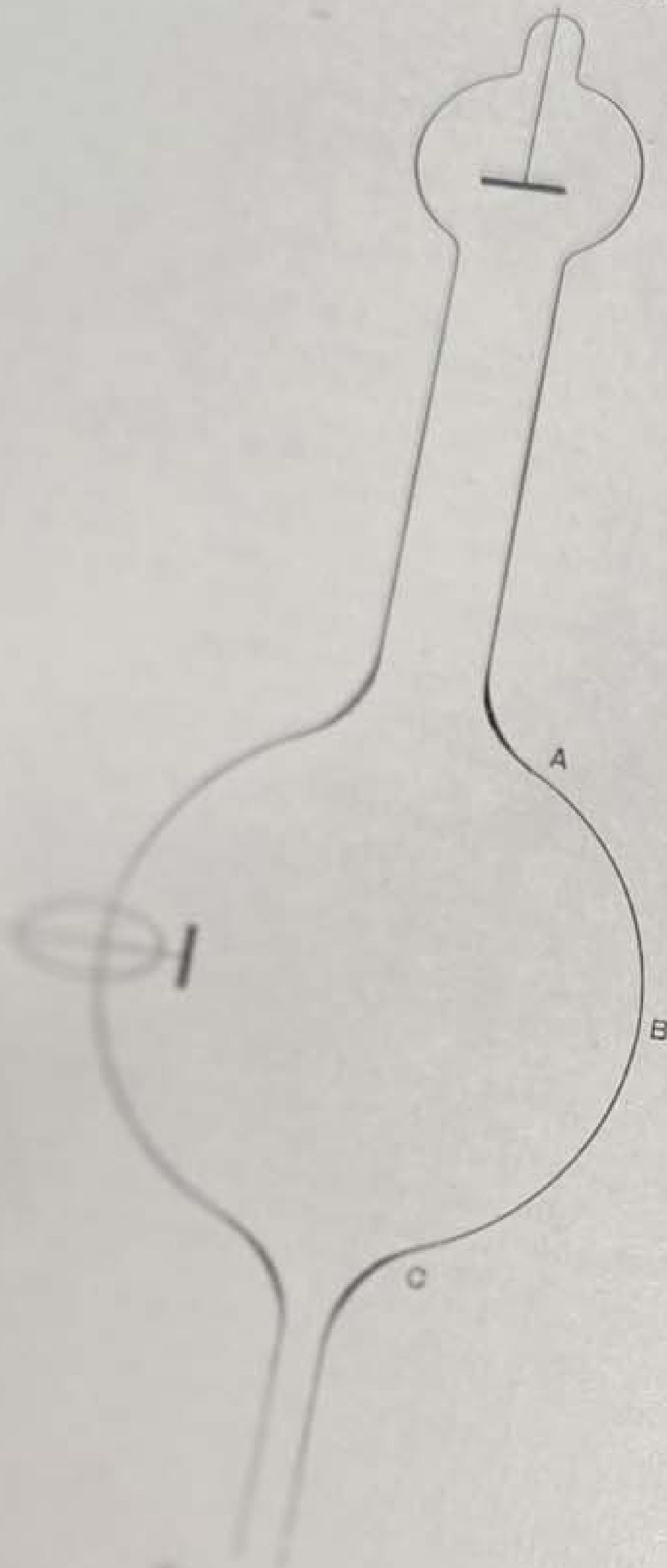


Fig. 1.

[illegible] the back of the grating, and, therefore, [illegible] plate. At two feet distance [illegible] shadowgraph is approximately [illegible] distance the time increases to [illegible] the duration of exposure may be [illegible] the square of the distance.

[illegible] as ordinarily employed for [illegible] rapid plates appear to be [illegible] i. e., to require least duration [illegible] slow plates appear to be [illegible] sensitiveness for Röntgen [illegible]. To test this a composite [illegible] strips, cut from plates of [illegible], and the shadowgraph of [illegible] with the bars at right angles [illegible]. For the same exposure [illegible] of the shadowgraph images [illegible] relation to the photo- [illegible] sensitometer numbers [illegible] the deepest images

[illegible] degree of exhaustion and [illegible] with the surface area of [illegible] tube exposing a [illegible] a more rapid action on a [illegible], but will require [illegible]. On the other [illegible] tube from the plate, the [illegible] the tube diminishes in [illegible] without a diaphragm. [illegible] the sharpest [illegible] a sharp image at [illegible] small tube at a [illegible] tubes experi- [illegible] in diameter and with [illegible] and with thin glass walls. A small tube requires a small e. m. f., so that tubes can be made to suit almost any induction coil.

7. For a given thickness of glass wall, [illegible] glass appears to give better results than lead glass. [illegible] glass employed gives a [illegible] fluorescence, [illegible] gives a greenish fluorescence. [illegible] for at least ten minutes after the [illegible] through the tubes. A particular [illegible] gauge glass gives apparently [illegible] results, but does not appreciably [illegible] tion of the current. The residual phosphorescence [illegible] been found to produce a visible photographic [illegible] phorescence yet observed is pale white, whatever the color of the preceding fluorescence under excitation.

8. The form of tube arrived at by a gradual process of selection is shown in Fig. 2. The length is about three times

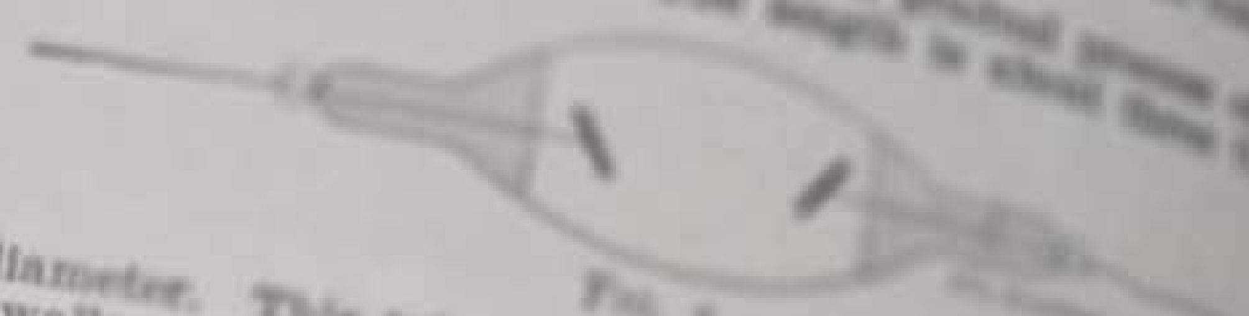


Fig. 2.

the diameter. This tube is made in various sizes. When the glass walls are made thin for producing the best photographic effect a spark is apt to pierce the wall and destroy the vacuum. Partly on this account, tinfoil caps are placed over the extremities of the tube, as indicated by the shaded areas in the sketch. These tinfoil caps are in connection with the electrodes and are cemented to the external surface of the tube by shellac.

9. It was found by repeated trials with many tubes that the fluorescent and photographic power of all the tubes without caps was greatly increased, roughly doubled, in fact, by bringing two metallic discs connected with the respective electrodes to the opposite points, as represented in Fig. 3. The supposition is that the tubes then become at once an ordinary and an electrodeless tube combined. The metallic caps above mentioned were the outcome of these experiments, and not only have all these capped tubes remained unperforated, but their fluorescent and photographic powers have been enchanced by the caps.

The caps serve three purposes: (a) To stop piercing by permitting excessive sparking to escape over the external surface. (b) To increase photographic and fluorescent power. (c) To prevent undue heating of internal electrodes and a consequent change of vacuum.

10. The exciting apparatus consists of a large Ruhmkorff coil capable of giving a 12-inch spark, although such a length of spark is rarely required.

The coil is usually excited from a 120-volt continuous-current circuit through a lamp bank of from eight to twenty 16-candle-power incandescent lamps arranged in parallel, with rapidly rotating wheel in.errupter, ariven by a small motor. About 400 interruptions are made per second, and the duration of closure in the circuit is twice that of opening. An air blast is directed upon the spark over the periphery of the interrupting wheel, through a fine nozzle. This tends to produce a sudden breaking of the circuit. It has been found that greatly improved results have followed the removal of the usual condenser and the substitution of the airblast. The resulting secondary e. m. f. is almost symmetrical like an alternating e. m. f., and the two electrodes in the tube are apparently equally active. The secondary terminals of the induction coil are led directly to the vacuum tube. If the airblast is removed and the condenser substituted, the fluorescent and photographic power of the tube is greatly diminished. The coil is sometimes excited directly through an interrupter from a battery of storage cells.

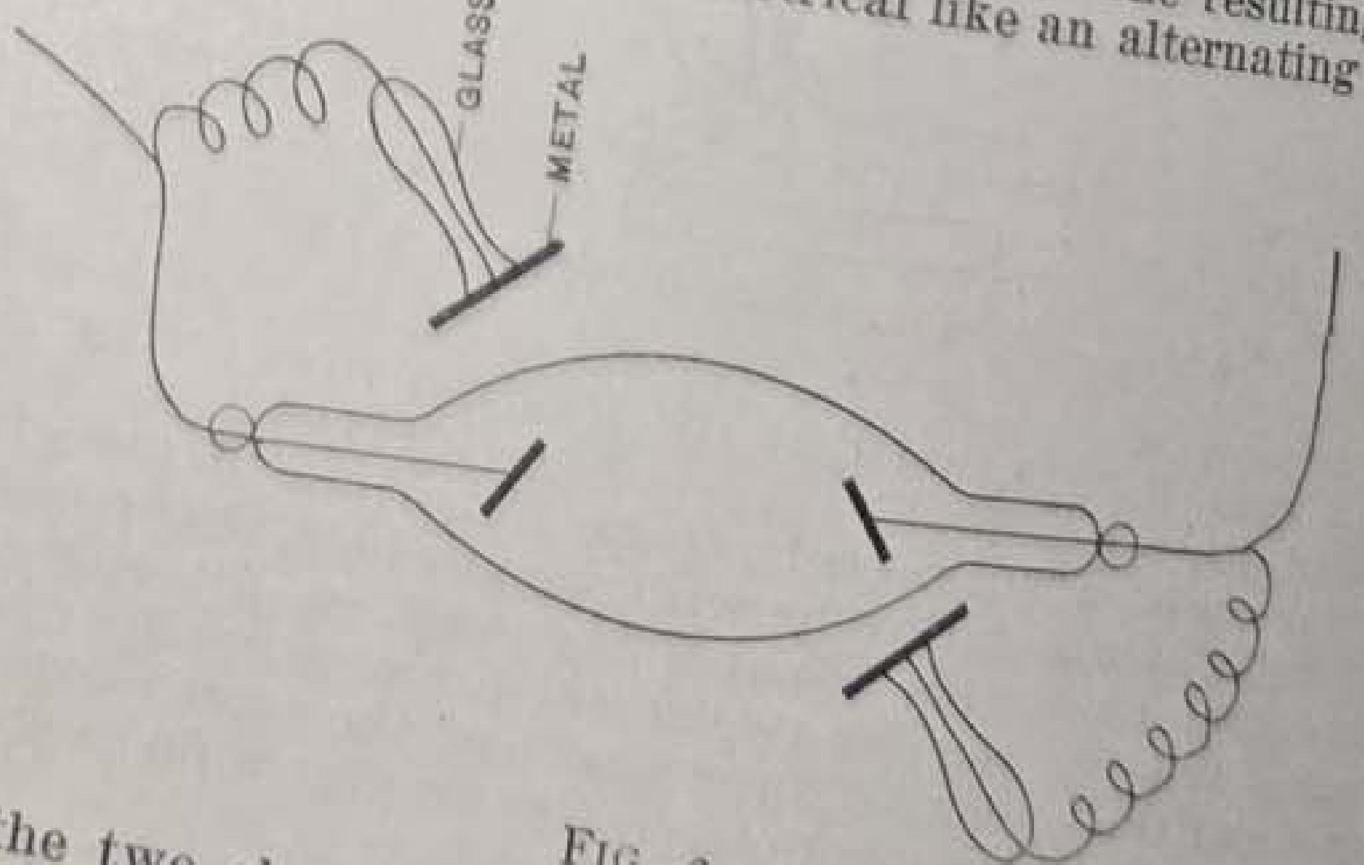


Fig. 3.

We believe that these observations of Mr. Edison cannot fail to be valuable to many practical workers with Röntgen rays. We hope to communicate further experimental results at some future time.

DO ORDINARY ILLUMINANTS GIVE OUT X-RAYS?

BY R. K. DUNCAN.

IT has been discovered by several investigators that a Welsbach burner or even an ordinary paraffin flame may be made to affect a covered sensitive plate and to give a shadow picture.

With the object of ascertaining whether this action was due to Röntgen rays, the writer made the following experiments:

1. We first obtained a shadow picture of a coin by placing both coin and plate in a carefully covered plate holder and exposing to the action of a Welsbach burner for seven hours at a distance of five inches. The result was a fairly good shadow picture. It was then apparent that if it took seven hours to obtain a picture from a Welsbach having a glass chimney over the incandescent mantle, it should take much less time if aluminum displaced the glass as a chimney, providing that the effect was due to X-rays, to the action of which aluminum is quite transparent.

2. A second experiment was made precisely similar to the first in time and method, except that aluminum was substituted for glass. After development, no image whatever was found upon the plates.

3. A third experiment similar to the second was tried and verified. This seems to dispose, then, of the idea that the effect is due to X-rays.

4. A fourth experiment was carried out with acetylene as the illuminant. A coin inside a watch glass was placed within a carefully covered plate holder and exposed for two hours to the action of two acetylene flames. After development an image of not only the coin, but the watch glass also, was found upon the plate, while a key wrapped up in aluminum gave nothing whatever.

Now, if the plate holder had been exposed to the action of X-rays from a Crookes tube we should have had a shadow of the watch glass without the case and a picture of the key in the aluminum.

The conclusion, therefore, which the writer draws from these experiments is that shadow pictures obtained from ordinary illuminants are not due to the action of X-rays. A fifth experiment shows that if the plate holder be placed within three inches of the Welsbach, so that it becomes hot, a very well defined shadow may be obtained in forty minutes. One may suspect, therefore, that the entire action is due to heat rays, or leakage of light through the cover of the sensitive plate.

ON RADIANT MATTER.—IV.

BY WILLIAM CROOKES, F. R. S.

IT is of great interest to ascertain whether the law governing the magnetic deflection of the trajectory of radiant matter is the same as has been found to hold good at a lower vacuum. The experiments just described were made with a very high vacuum. Fig. 16 represents a tube with a low vacuum. When the induction spark is turned on, it passes as a narrow line of violet light joining the two poles. Underneath is a powerful electromagnet. On making contact with the magnet, the line of light dips in the center towards the magnet. On reversing the poles, the line is driven up to the top of the tube. We notice the difference between the two phenomena. Here the action is temporary. The dip takes place under the magnetic influence; the line of discharge then rises and pursues its path to the positive pole. In the high exhaustion, however, after the stream of radiant matter had dipped to the magnet, it did not recover itself, but continued its path in the altered direction.

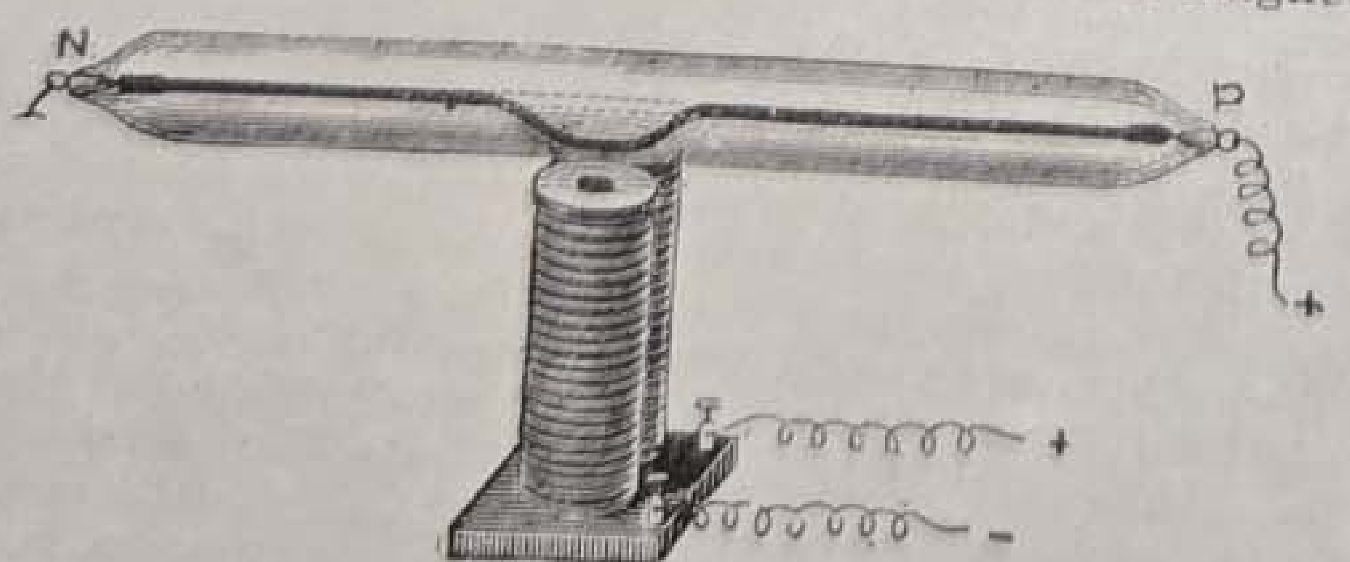


FIG. 16.

By means of the little wheel (Fig. 17) skillfully constructed by Mr. Gimingham, Mr. Crookes was able to show the magnetic deflection in the electric lantern. The negative pole (a, b) is in the form of a very shallow cup. In front of the cup is a mica screen (c, d), wide enough to intercept the radiant matter coming from the negative pole. Behind this screen is a mica wheel (e, f) with a series of vanes, making a sort of paddle wheel. So arranged, the molecular rays from the pole a b will be cut off from the wheel, and will not produce any movement. A magnet, g, was now put over the tube, so as to deflect the stream over or under the obstacle c d, and the result was rapid motion in one or the other direction, according to the way the magnet was turned. The image of the apparatus was thrown on the screen. The spiral lines painted on the wheel showed which way it turned. The magnet was arranged to draw the molecular stream so as to beat against the upper vanes, and the wheel revolved rapidly as if it were an overshot water wheel. On turning the magnet so as to drive the radiant matter underneath, the wheel slackened speed, stopped, and then began to rotate the other way, like an undershot water wheel. This reversal can be repeated as often as the position of the magnet is reversed.

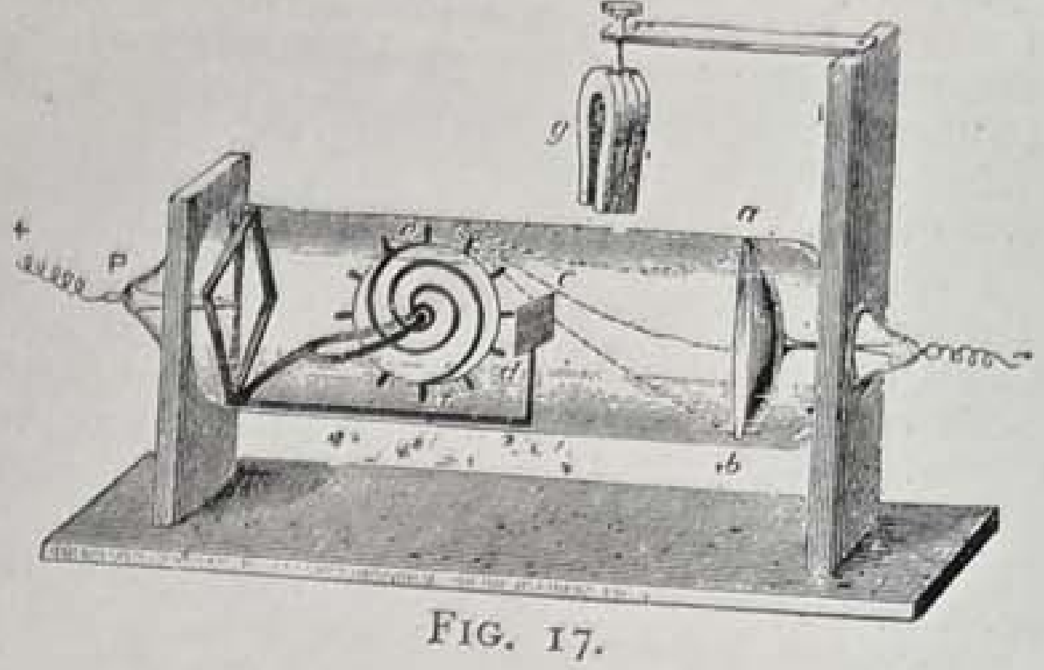


FIG. 17.

We have mentioned that the molecules of the radiant matter discharged from the negative pole are negatively electrified. It is probable that their velocity is owing to the mutual repulsion between the similarly electrified pole and the molecules. In less high vacua, such as that shown in Fig. 16, the discharge passes from one pole to another, carrying an electric current as if it were a flexible wire. Now it is of great interest to ascertain if the stream of radiant matter from the negative pole also carries a current. Fig. 18 is an apparatus which decides the question at once. The tube contains two negative terminals (a, b) close together at one end, and one positive terminal (c) at the other. This enables two streams of radiant matter to be sent side by side along the phosphorescent screen, or by disconnecting one negative pole, only one stream.

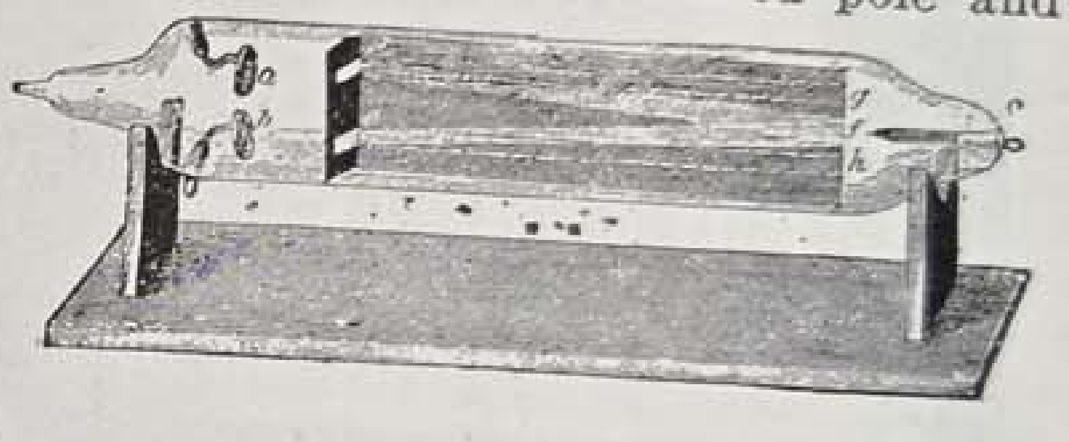
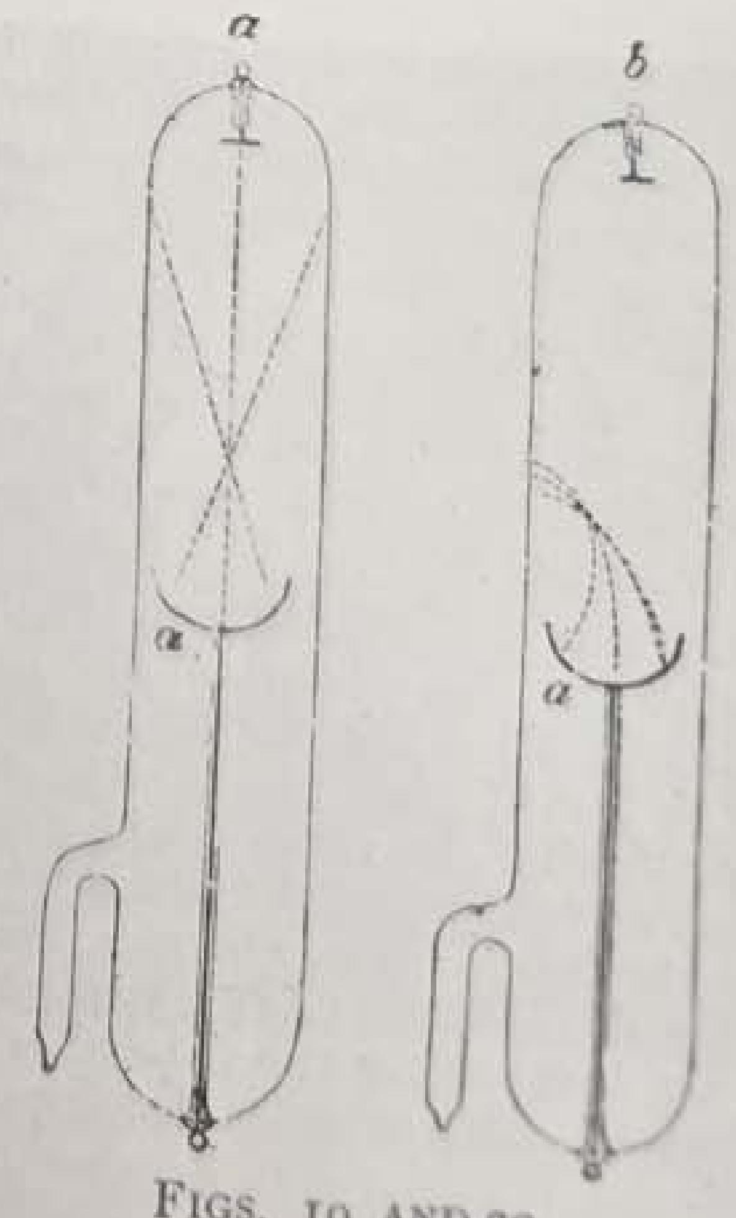


FIG. 18.



FIGS. 19 AND 20.

If the streams of radiant matter carry an electric current, they will act like two parallel conducting wires and attract one another; but if they are simply built up of negatively electrified molecules, they will repel each other.

The upper negative pole (a) was first connected with the coil, and the ray was seen shooting along the line d, f. The

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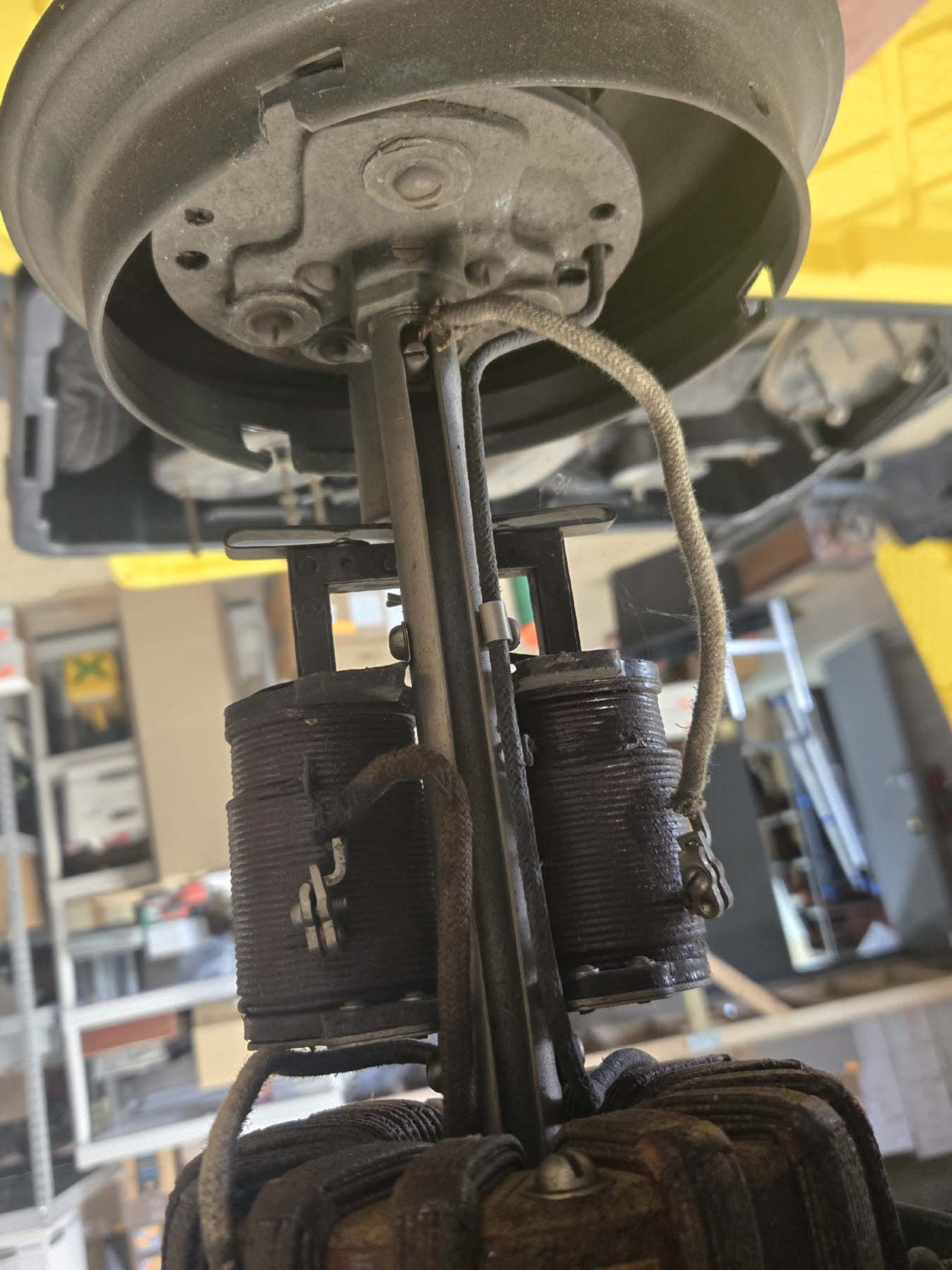

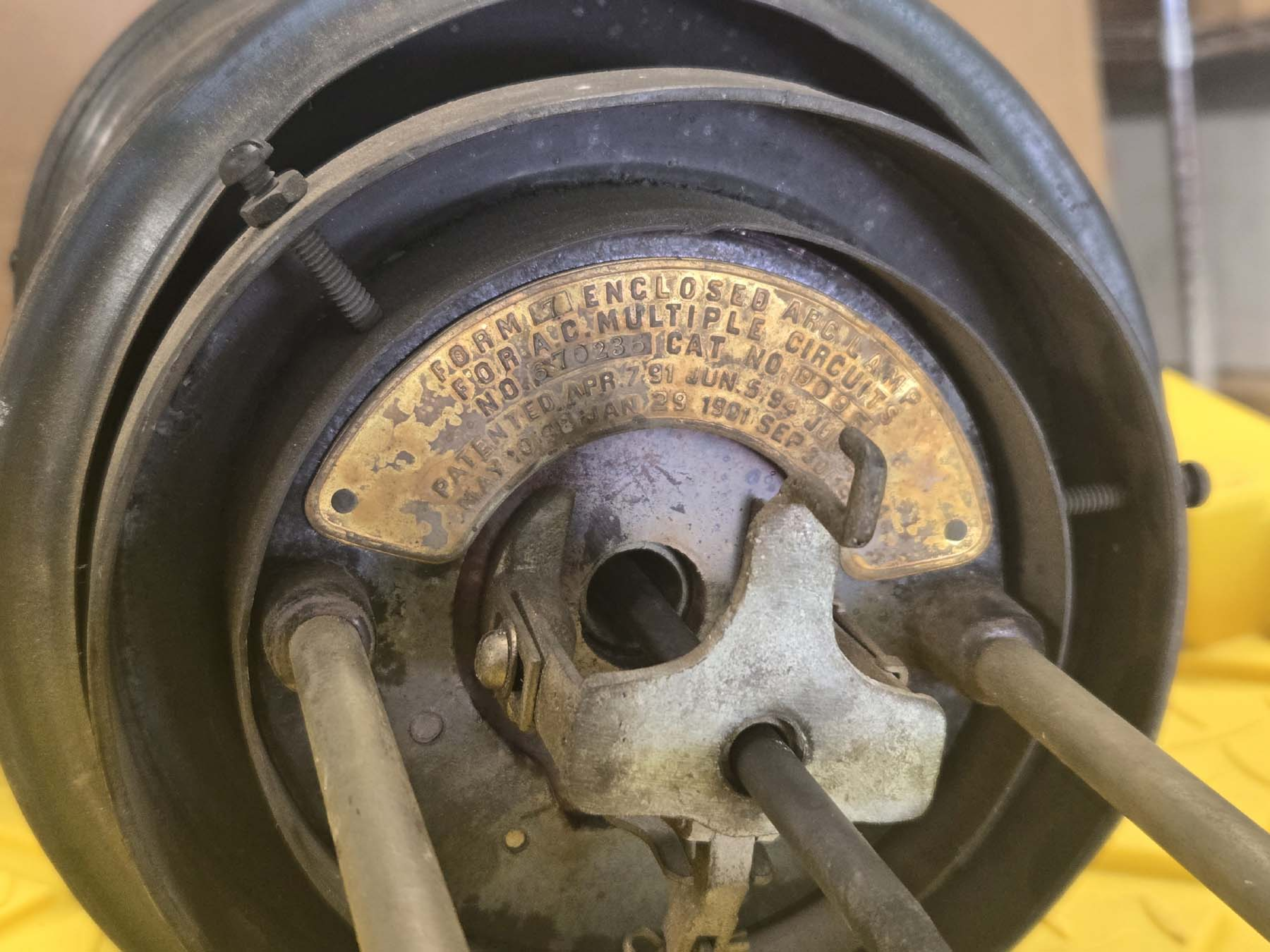
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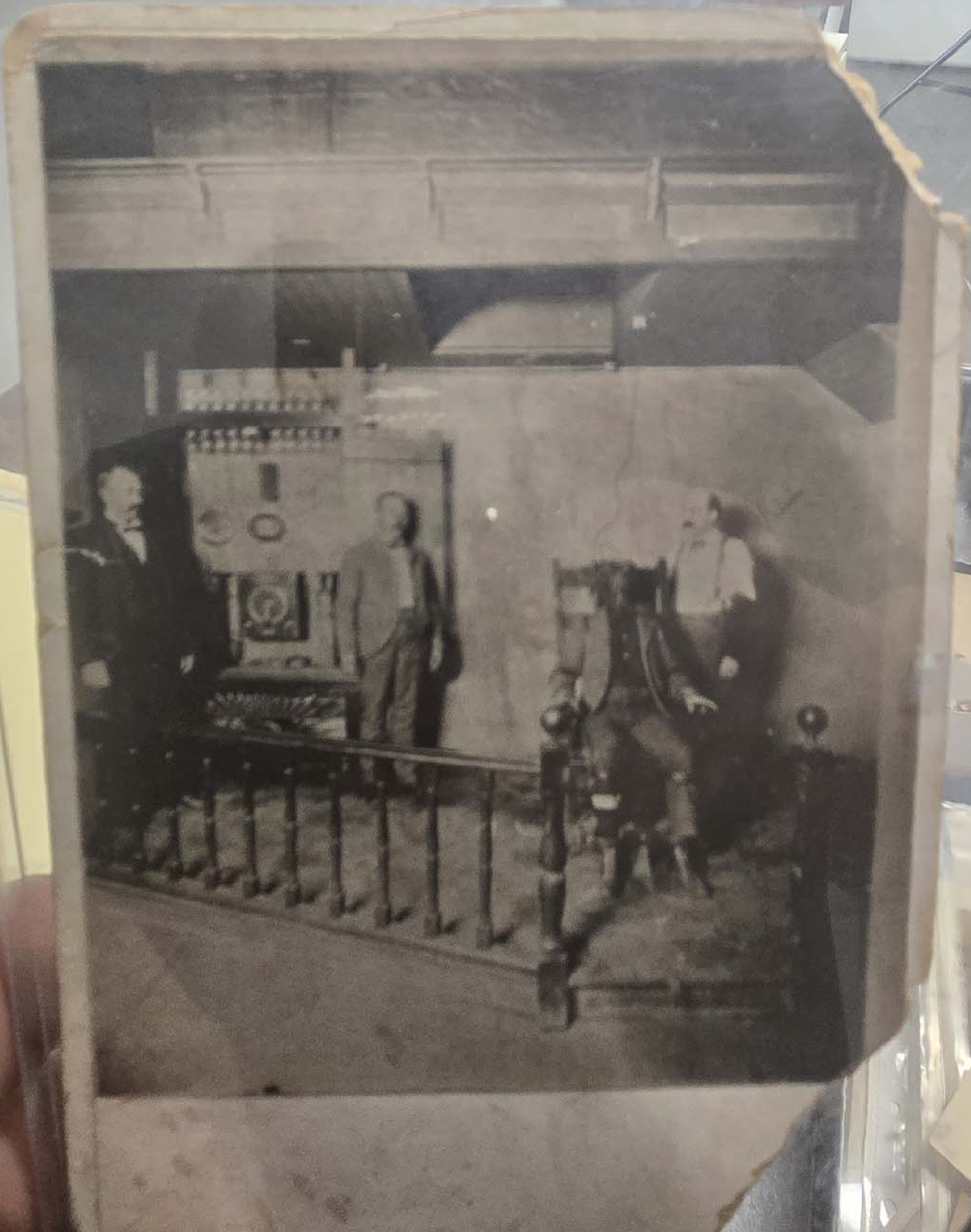

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		1	25 " N.S. " "			27	✓	
	✓	1	*2 switch		1	25	✓	
6		4	*0 "	.35	1	40	✓	
35		20	Sockets Porc. Reg.	.50	10		✓	
35		20	Bushings	.00		00	✓	
24		36	3¼ in shade holders	.10	3	60	✓	
14"		36	10. flat porc. shades	.15	5	40		10
		20½ lbs.	*14 Und. wire	.23	4	72	✓	
	✓	18 "	*16 " "	.24	4	32	✓	
	✓	24 "	" 6 " "	.20	4	80	✓	
Wolf		¾ "	white tape	.75		56		25
	✓	54 ft.	¼ in tubing	.02	1	08	✓	
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APRIL 1, 1894.

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" " " 500 "	60.00
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We guarantee our Apparatus for one year from date of sale.

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TRADE MARK

Claflin & Kimball
NEW ENGLAND AGENTS.
The Mather Electric Co.
The Perkins Electric Lamp Co.
105 Summer St. Boston, April 6/91—

Farr Alpaca Co.
Holyoke, Mass.

Gentlemen;

In accordance with the conversation with our Mr. Claflin on Saturday, we would submit the following figures for an Arc light plant for your mill.

We will install on proper foundation provided by you one Arc dynamo of a maximum capacity of 50-1200 c.p. arc lamps with regulator for same.

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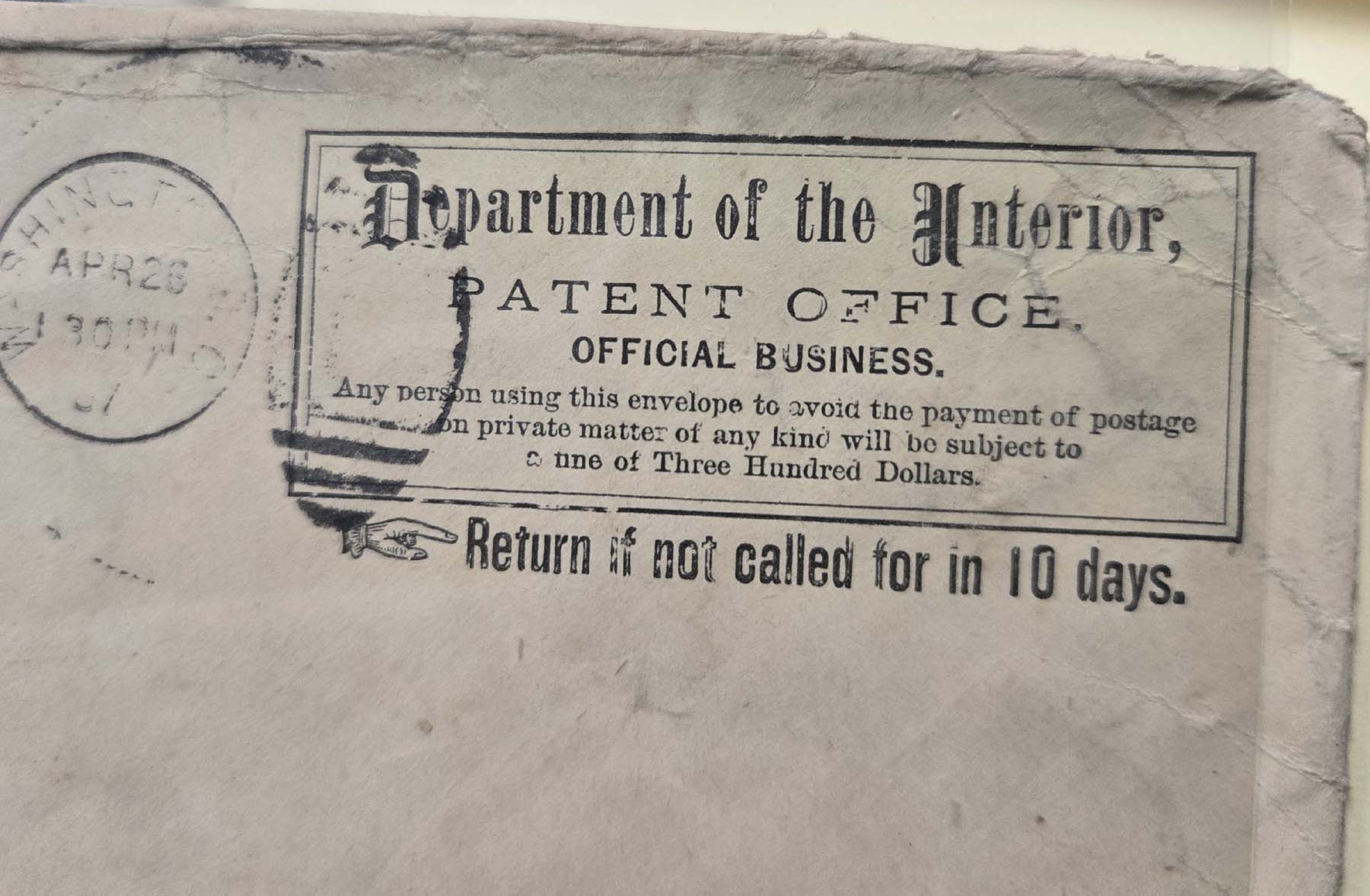

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Westinghouse

Electric and Manufacturing Co's Apparatus

. . AT THE . .

Columbian Exposition.

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venue.

Bldg.

WESTINGHOUSE

Electric and Manufacturing Company's Apparatus

—AT THE—

COLUMBIAN EXPOSITION.

The grounds and buildings of the Exposition are lighted by the Westinghouse alternating current system, supplying Sawyer-Man two-part or stopper incandescent lamps. In carrying out this work, the Westinghouse Electric & Manufacturing Co. has installed in the south aisle of *Machinery Hall* the largest electric plant in the world. This plant is capable of simultaneously supplying 189,600 sixteen candle power lamps. It is noteworthy, not only on account of the number and capacity of the machines installed, but also for the reason that the current supplied is adapted to the operation of the celebrated Tesla polyphase alternating current motors and to the supplying of arc lamps as well as incandescent lamps.

To the east of the above plant, in the same building, is a 750 horse-power, slow speed, direct current, six pole railway generator, which has its armature mounted upon the shaft of an Allis engine.

In the *Electricity Building*, the exhibits of the Company occupy about 15,000 square feet of floor space, and while the standard Westinghouse alternating current lighting apparatus is fully illustrated, special attention has been directed to the setting forth of new features and apparatus illustrating recent developments and improvements in electric railway practice, power transmission and in other branches of the field of applied electricity. Furthermore are shown exhibits of apparatus used by Mr. Nikola Tesla in the development of his polyphase systems and arrangements are made for experimentally showing his high potential and high frequency phenomena.

The head of Columbus, occupying the large wall space at the south end of Electricity Building, together with the decorative scrolls and letters, are made up of *Sawyer-Man stopper incandescent lamps* lighted by current from the circuits of the Exposition Company, which are supplied by the Westinghouse Central Station plant in Machinery Hall.

The machinery in the *Mines and Mining Building* is operated by two 150 horse-power, 500 volt, direct current Westinghouse motors, situated near the east entrance.

In the *Transportation Building*, Section C, Space 2, occupied by the New South Wales exhibit, a 20 horse-power Westinghouse motor operates an elevator manufactured by the Standard Screw Elevator Manufacturing Company, New York and Baltimore.

In the center aisle of the *Palace of Mechanic Arts*, a 20 ton 75-foot crane, manufactured by the Yale & Towne Manufacturing Company, is operated by Westinghouse motors of the Manchester type.

CENTRAL STATION LIGHTING AND POWER PLANT,

Used for Lighting Grounds and Buildings of Exposition.

This plant is located in Machinery Hall, "Power Plant, Column E 13 to Column E 25," and consists of the following apparatus:

Two 750 kilowatt two-phase alternators, belt driven by a 3,000 horse-power Allis Engine.

One 750 kilowatt two-phase alternator, belt driven by a 1,000 horse-power Fraser & Chalmers Engine.

One 750 kilowatt two-phase alternator, belt driven by a 1,000 horse-power McIntosh & Seymour engine.

One 750 kilowatt two-phase alternator, belt driven by a 1,000 horse-power Buckeye engine.

One 750 kilowatt two-phase alternator, belt driven by a 1,000 horse-power Atlas engine.

Six 750 kilowatt two-phase alternators, each driven by a 1,000 horse-power Westinghouse Columbian Steeple engine.

Two 240 kilowatt single-phase alternators, each belt driven by a 350 horse-power Westinghouse Compound engine.

Three 75 kilowatt exciters, direct driven by Westinghouse 100 horse-power Compound engines.

Complete marble switch-board for twelve two-phase alternators, two single-phase alternators, four exciters and forty circuits.

The switch-board controls all incandescent lights and a large number of arc lights throughout the Exposition grounds, including the Midway Plaisance. The switching devices are so arranged that any one of the forty circuits may be instantly connected to any one of the fourteen alternators, and regulating apparatus is provided for accurately adjusting the candle power of the lamps supplied from the various circuits.

The switch-board and the space occupied by the alternators and engines is lighted by Sawyer-Man stopper incandescent lamps and by Westinghouse constant potential alternating current arc lamps.

ELECTRIC TRANSMISSION OF POWER.

A complete plant illustrating electric transmission of power, as accomplished by the Tesla polyphase alternating current system, is shown in Section J, Space 2, north center of Electricity Building. This plant comprises a Generating Station, a High Tension Transmission Circuit, and a Receiving and Distributing Station.

GENERATING STATION (North of Pavilion). This station comprises the following:

One 500 horse-power, two-phase alternating current generator, driven by an electric motor.

One 5 horse-power, direct current exciter.

One complete marble switch-board.

Raising or step-up transformers which receive alternating current at moderate potential from a two-phase generator and deliver alternating current at high potential to a high tension circuit.

In practice the generator and exciter would be driven by water power or steam engine, but, since no such power is here available, the generator is belt driven by a 500 horse-power Tesla polyphase motor of the rotating field type, while the exciter is direct driven by a 5 horse-power motor of the same type. Both of these motors are operated by current from the ordinary lighting circuits of the Exposition, which are supplied from the large Westinghouse two-phase alternators in Machinery Hall.

TRANSMISSION CIRCUIT.—The switch-board at the generating station is connected with the switch-board at the receiving or distributing station by an overhead four-wire circuit west of the pavilion. The insulators supporting this circuit are of the type designed by the WESTINGHOUSE ELECTRIC & MANUFACTURING Co., and now in successful commercial use in the installation constructed for the San Antonio Light & Power Company of Pomona, California, where energy at 10,000 volts potential is transmitted by an overhead circuit of bare copper wire, No. 7, B. & S. gauge, to a distance of 28 miles. This is the greatest distance over which energy has hitherto been economically and successfully transmitted, but much greater distances are within the range of commercially successful attainment.

RECEIVING STATION (South of Pavilion).—The apparatus at the receiving station, which we may suppose to be located many miles from the generating station, with which it is connected by the overhead transmission circuit, comprises the following:

Reducing or step-down transformers which receive high potential alternating current from the transmission circuit and deliver alternating current at moderate potential to various local circuits.

Complete marble switch-board for receiving station.

500 horse-power, two-phase Tesla motor and rotary transformer.

This machine receives alternating current from the reducing or step-down transformers, and its function is two-fold.

FIRST.—It operates as a motor to drive:

a. Worthington pump.

b. A 40-light Westinghouse alternating current arc light dynamo.

SECOND.—It delivers as a rotary transformer, direct current at a potential of 500 volts used for operating:

a. Two 30 horse-power Westinghouse street railway motors, single reduction type, mounted upon a standard Dorner & Dutton truck.

b. A 60 horse-power direct current motor, driving an Ingersoll-Sergeant air compressor.

c. Direct current constant potential arc lamps.

60 horse-power, rotary transformer.

This machine is supplied with two-phase alternating current from the reducing or step-down transformers and delivers direct current at 50 volts potential for the operation of a large Schuckert search light located in adjoining exhibit. The machine is also adapted to electrolytic work, charging of storage batteries, etc.

60 horse-power, two-phase Tesla motor—Synchronous type.

This motor is direct coupled to a 45 kilowatt Westinghouse slow-speed alternator of the constant potential type, used for incandescent lighting.

This system, while it permits the use of very high potential alternating current, required for transmission over great distances, delivers both alternating and direct current at any potential desired. It is therefore adapted to any kind of service to which electricity is applicable, and, as illustrated in this exhibit, both alternating and direct current for any kind of lighting or power service, or for electrolytic work, may be obtained from a single generator and a single transmission circuit.

The application of this system to mining operations is of special interest and importance. It will be noted that the

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direct current from the rotary transformers is excellently adapted to haulage and hoisting purposes, etc., while the air compressor, used to operate standard pneumatic drills, may be driven, as in this instance, by a direct current motor, supplied from the rotary transformer, or by a Tesla polyphase motor, supplied with alternating current from the reducing transformers.

STREET RAILWAY APPARATUS.

The exhibit of apparatus for the operation of Street Railways by electricity, shown in Electricity Building, Section H, Space 1, south of the center of the building, comprises the following:

One 270 horse-power multipolar generator direct driven by Westinghouse compound engine.

One 400 horse-power multipolar generator, belt-driven type.

Westinghouse Street Railway motors—single reduction type—20, 25 and 30 horse-power capacity.

One Brownell 20 feet car equipped with two 30 horse-power Westinghouse motors—single reduction type—series multiple controller, etc., etc.

One Stevenson 18 feet car equipped with two 30 horse-power Westinghouse motors—single reduction type—series multiple controller, etc., etc., and having a glass floor to show the operation of one of the motors.

Complete line of switches.

Complete line of ammeters and voltmeters.

Complete line of Westinghouse automatic circuit breakers.

Lightning arresters.

Switch-board fittings and connections.

Motor details illustrating construction.

Exhibit in Transportation Building, Sec L-N, Space 9 to 11.

One Lamokin 18 feet car equipped with two 30 horse-power Westinghouse motors—single reduction type—series multiple controller, etc., etc.

Exhibit on outside exhibition track near north end of Terminal Station.

One Laclede 20 feet car equipped with two 30 horse-power Westinghouse motors—single reduction type—series multiple controller, etc., etc.

Exhibit in Machinery Hall, Power Plant, Column C 7.

One 750 horse-power railway generator, the armature of which is mounted upon the shaft of an Allis engine. This machine operates at the extremely low speed of 90 revolutions per minute.

One complete marble switch-board for one generator and four circuits.

The railway system of the WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY is exclusively used by the South Chicago Street Railway Company and by the Chicago City Railway Company. The cars of these Companies daily carry thousands of passengers to and from the exposition. They can be seen on Stony Island Avenue, near the 62d and 64th Street entrances.

APPARATUS FOR ARC AND INCANDESCENT LIGHTING.

Spaces 1 and 2, Section B, Electricity Building, contain apparatus for arc and incandescent lighting. These exhibits comprise the following:

Standard Westinghouse alternators of various sizes, including a field casting of a 450 kilowatt standard belt-driven alternator, showing Westinghouse method of casting laminated poles into cast iron frame.

Standard Westinghouse converters and transformers.

Special converters equipped with non-arcing metal lightning arresters.

Direct current motors and generators of the horizontal type.

Direct current generators and motors of the "letter" type

Direct current generators of the multipolar type.

Direct current motors of the Manchester type.

Alternating current arc light dynamos.

Shallenberger alternating current meters, complete and in operation; also parts illustrating construction.

Wurts non-arcing metal lightning arresters for alternating current circuits.

Lightning arresters of various types for direct current circuits.

Complete line of switches for alternating current work.

Complete line of switches for direct current work.

Complete line of ammeters and voltmeters for alternating currents.

Complete line of ammeters and voltmeters for direct currents.

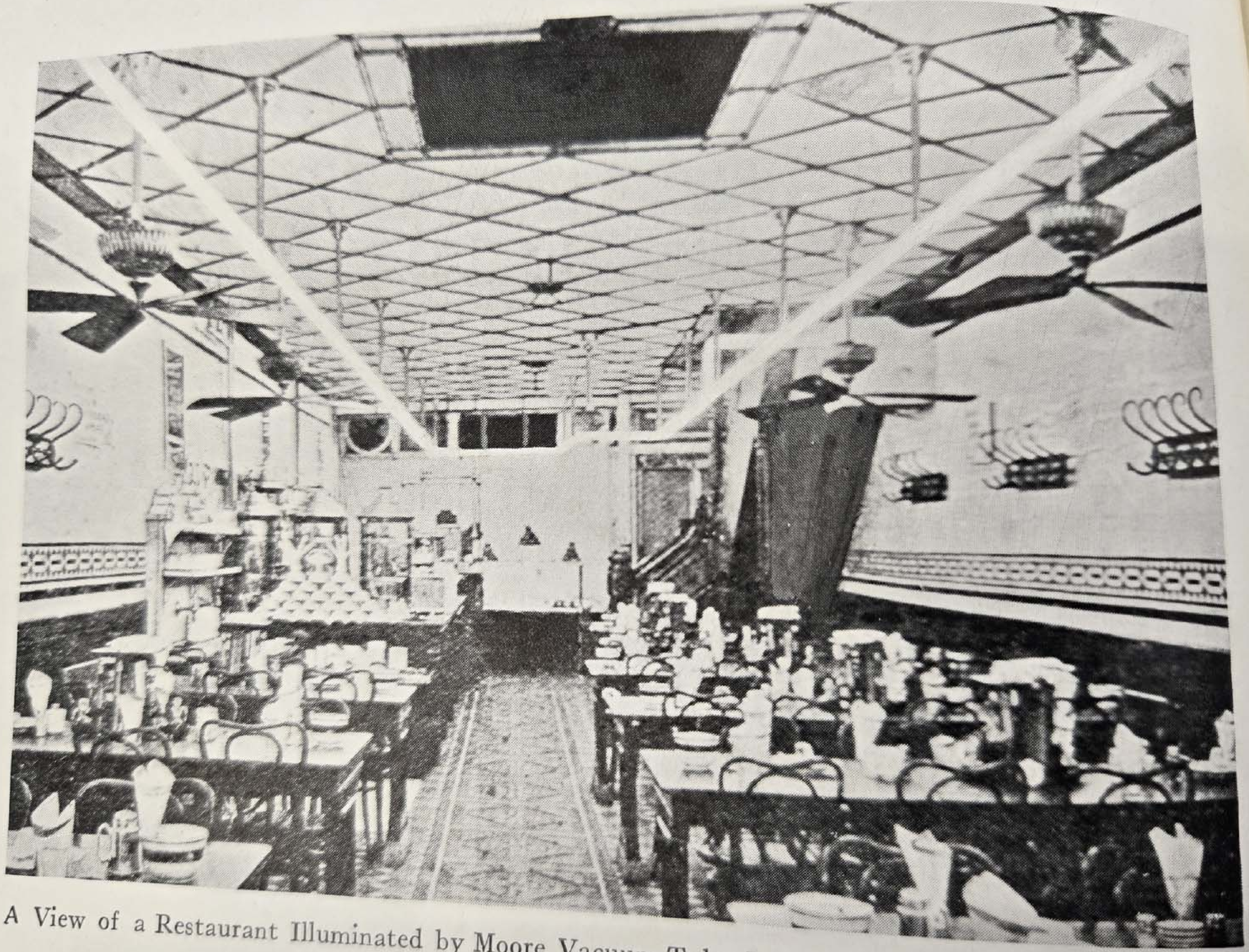
NIKOLA TESLA'S APPARATUS

AND HIGH POTENTIAL PHENOMENA.

In Section B 1, opposite the space occupied by the Railway Exhibit, may be found a collection of the various forms of motors and other apparatus used by Nikola Tesla in the discovery and development of the polyphase system.

On a table near the main aisle is a Tesla ring which illustrates the principle of the rotating magnetic field. The apparatus consists of two coils of wire, through which two alternating currents differing in phase are passed. The effect produced upon metallic bodies placed within the influence of this field is practically the same as though a magnet were rapidly revolved around the axis of the coils. The action of this ring, as illustrated by its effect upon the *Columbus Egg*, may be seen daily, except Sunday, during the first fifteen minutes of each hour, from 3 P. M. until 10 P. M.

Near the above exhibit is a dark room erected for special exhibits of high potential and high frequency phenomena. Here are given exhibitions of luminous bulbs, high potential discharges and other effects illustrating the remarkable results obtained by Mr. Tesla in the use of high frequency alternating currents.



A View of a Restaurant Illuminated by Moore Vacuum Tube Lamps fixed to the ceilings giving a very pleasant diffused light.

are put through them, being delivered close to the tips by roller contacts. To prevent rapid burning away of the carbons a jet of methylated spirit vapour is blown upon them. The result is an intensely brilliant crater of about four times the intrinsic brilliancy of an ordinary open arc, and when placed in the focus of a parabolic mirror, it gives a searchlight beam of about three times the intensity compared with the ordinary arc-projector of the same mirror area.

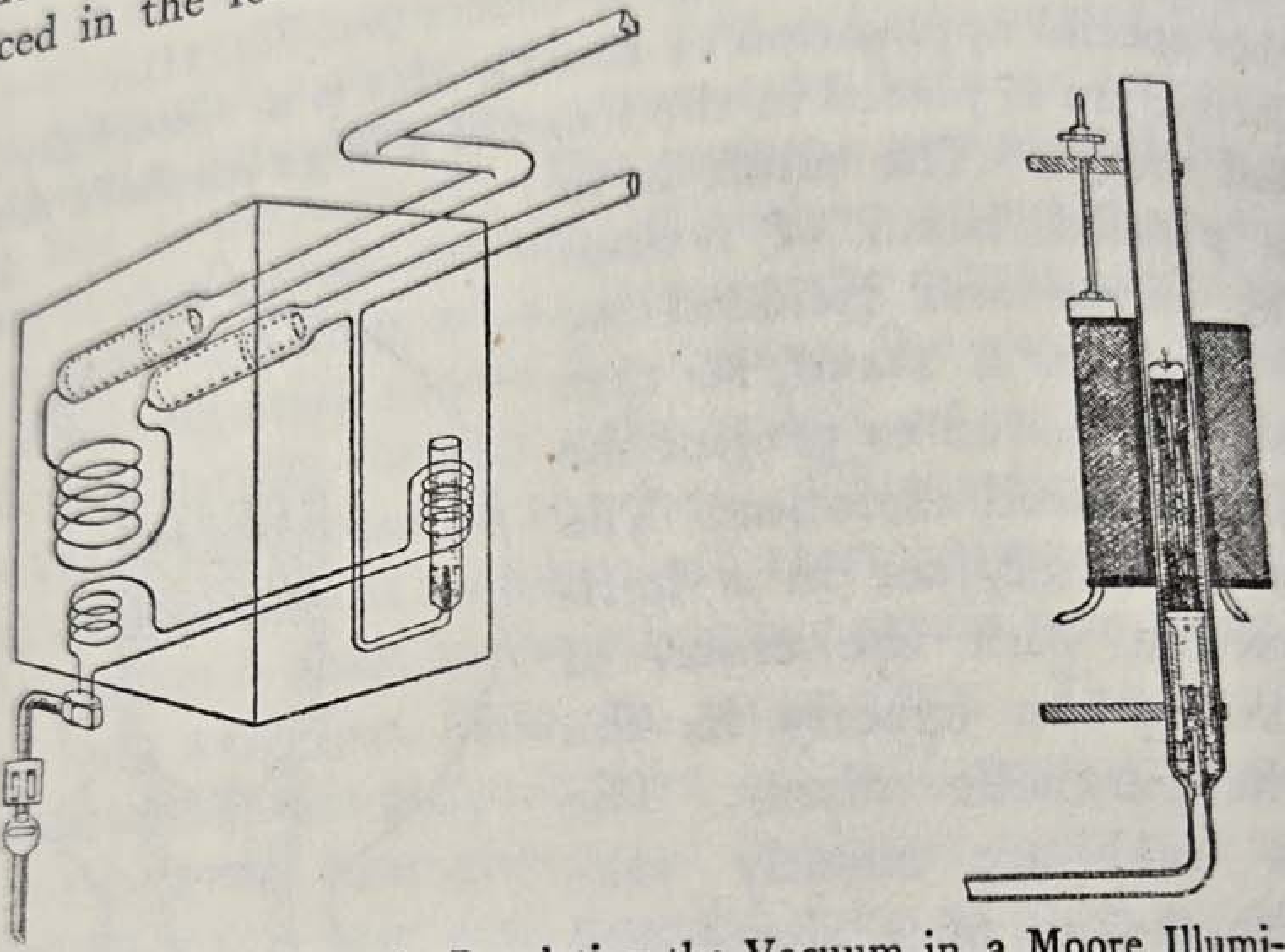


Fig. 12.—Arrangements for Regulating the Vacuum in a Moore Illuminating Vacuum Tube. The electromotive force is supplied to the tube by means of an alternating current transformer, the coils of which are shown as two spirals in the left-hand figure. Any increase of resistance of the tube causes the primary current to act on a valve which admits a little more air or other gas to the tube.

A few special types of electric lamp which have limited uses may be mentioned in conclusion.

The mercury vapour arc lamp is the invention of Mr. Cooper Hewitt, and is very efficient, yielding a light of 1 c.p. for 0·6 of a watt, or 1·66 c.p. per watt. It is produced by placing mercury in a highly exhausted glass tube having wire electrodes sealed through the glass tube ends, which project into pools of mercury kept at the tube ends in bent portion of it. The arc is started by tilting the tube so that a stream of mercury unites the two pools for a moment and then separates. The arc is then formed and kept up by an electric discharge through mercury vapour. The light is of an intense green and highly actinic. Hence it is useful for photography of certain kinds, but as it gives the human complexion a very ghastly appearance it is not suited for general use.

Vacuum tubes containing neon, one of the rare atmospheric gases, have been used as illuminants to some extent. When a high-voltage electric discharge is sent through neon at low pressure contained in a glass tube having platinum electrode wires sealed into the ends, the gas glows with a brilliant rosy light (see Plate 12, page 175). A 20-foot tube can be made to yield a light of 900 c.p., with a power expenditure of about 1·3 watts per c.p. Such vacuum tubes have been used to a limited extent for lighting.

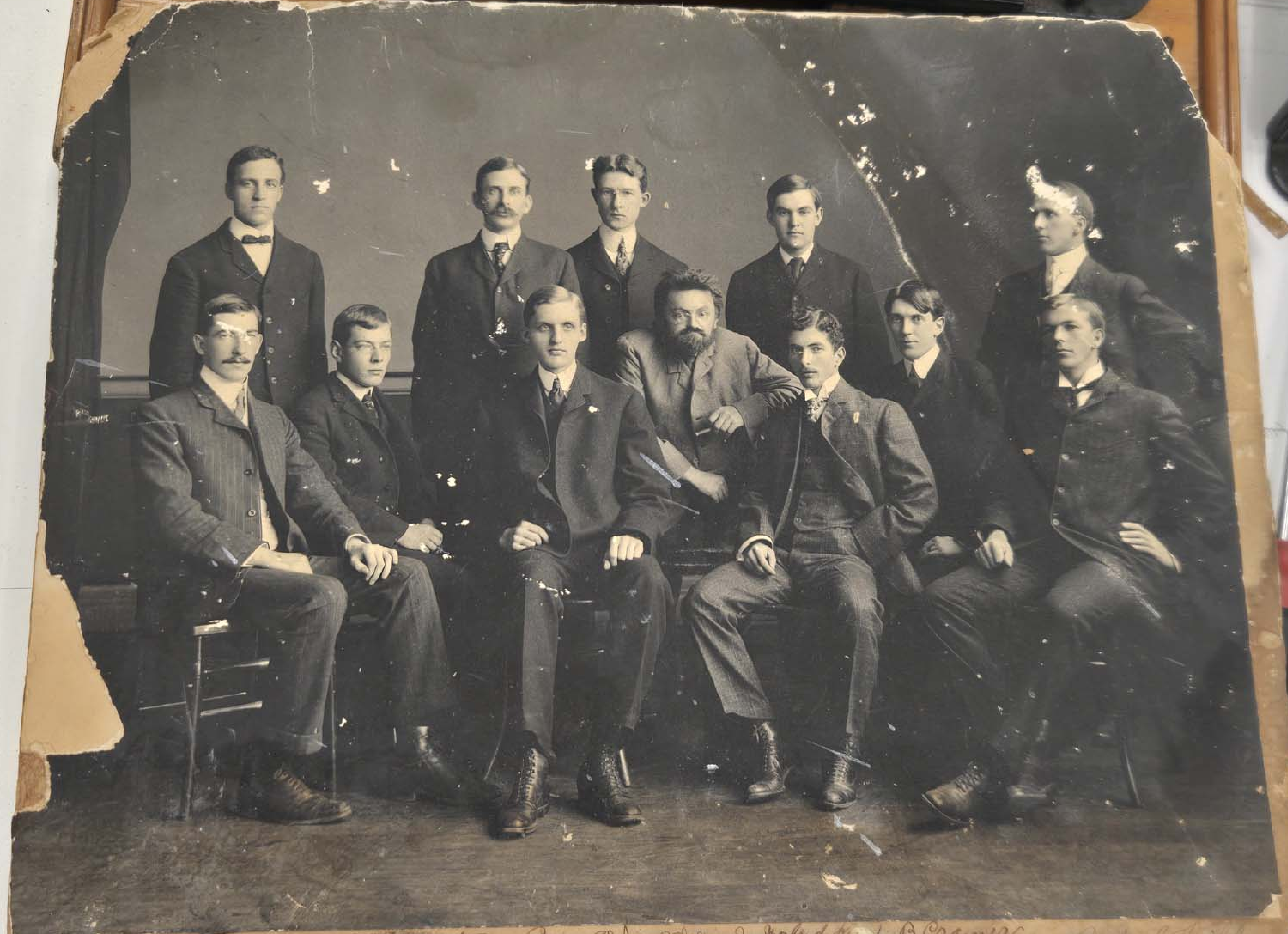
In September, 1907, the author tested and reported upon a system of vacuum tube lighting due to Mr. D. Macfarlane Moore. The rarefied gases used in the tube were either air nitrogen, or carbon dioxide, and were contained, at a pressure of 1 or 2 millimetres, in long glass tubes with platinum electrodes sealed into each end. The high voltage current required to make the gas glow was provided by an alternating current transformer. As the tube is worked the vacuum continually gets higher, due to absorption of the gas. Hence an important element of the invention consisted in a "breathing valve," by means of which a small amount of fresh gas was admitted to the tube from time to time. This was automatically done by the decrease in the electric current which takes place as the vacuum becomes too high (see Fig. 12).

The glass tubes used are about 2 inches in diameter and 10—20 feet long, and the voltage required is about 75 volts per foot run of tube. The light emitted varies with the gas used. Nitrogen gives a rosy-yellow, and has an efficiency of about 0·6 c.p. per watt expended.

The intrinsic brilliancy is low, only 1 to 2 c.p. per square inch, but this renders diffusing globes unnecessary. Lamps up to 200 or 300 feet in length can be used, and they are convenient for certain kinds of shop and outdoor lighting. The only risk attending them is the high voltage required at the terminals.

A full description of the Moore light and its mode of use was given by the author in an article published in *The Illuminating Engineer* for 1908, Vol. I., p. 19, entitled "Vacuum Tube Lighting."

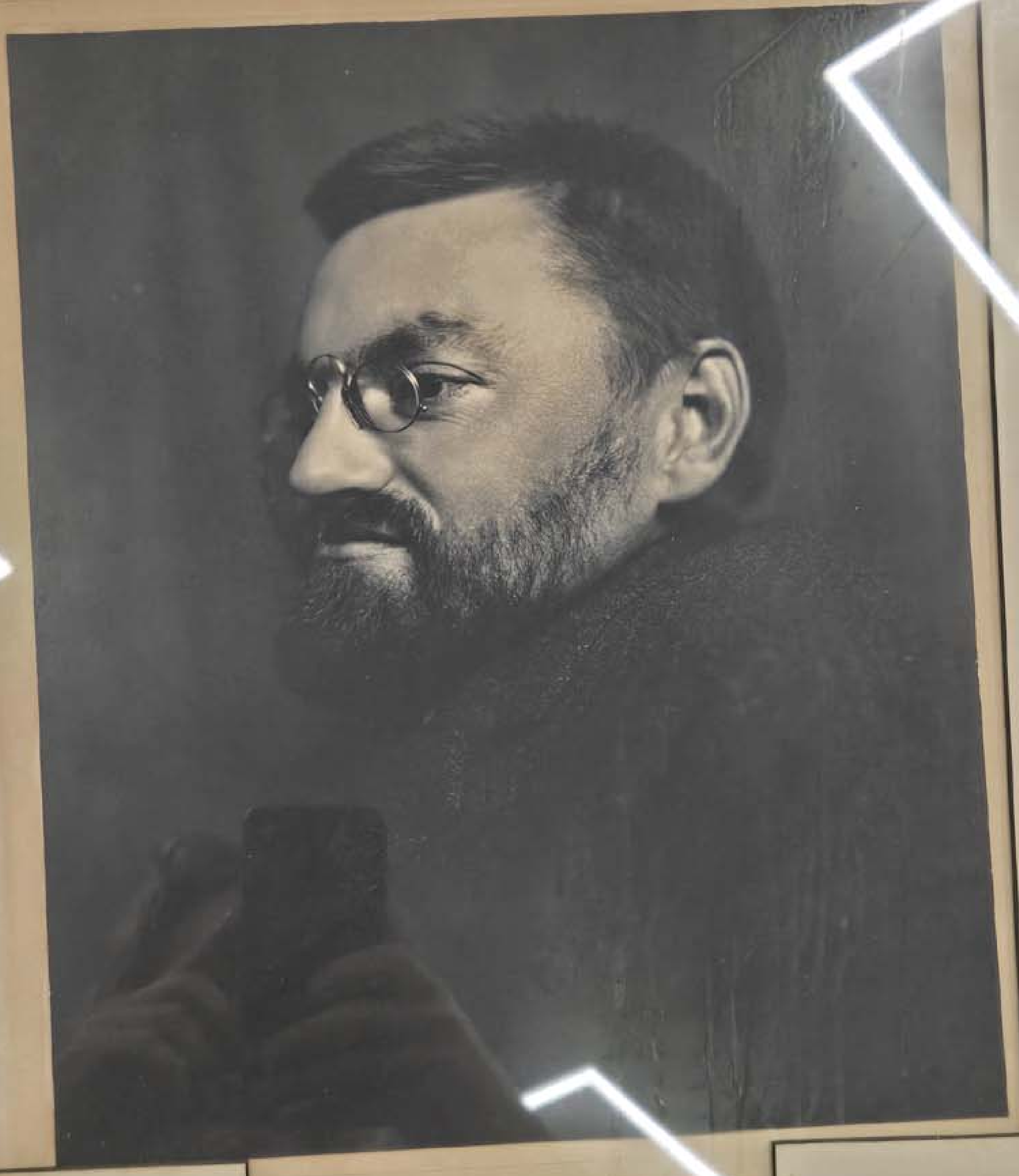
"TOO DUMB FO
TOO UGLY F
3589
DO NOT PARK



Wm O. Morse E. E. F. Creighton Ross St J. McClelland Morland M[illegible] L B Cramer [illegible] Withers

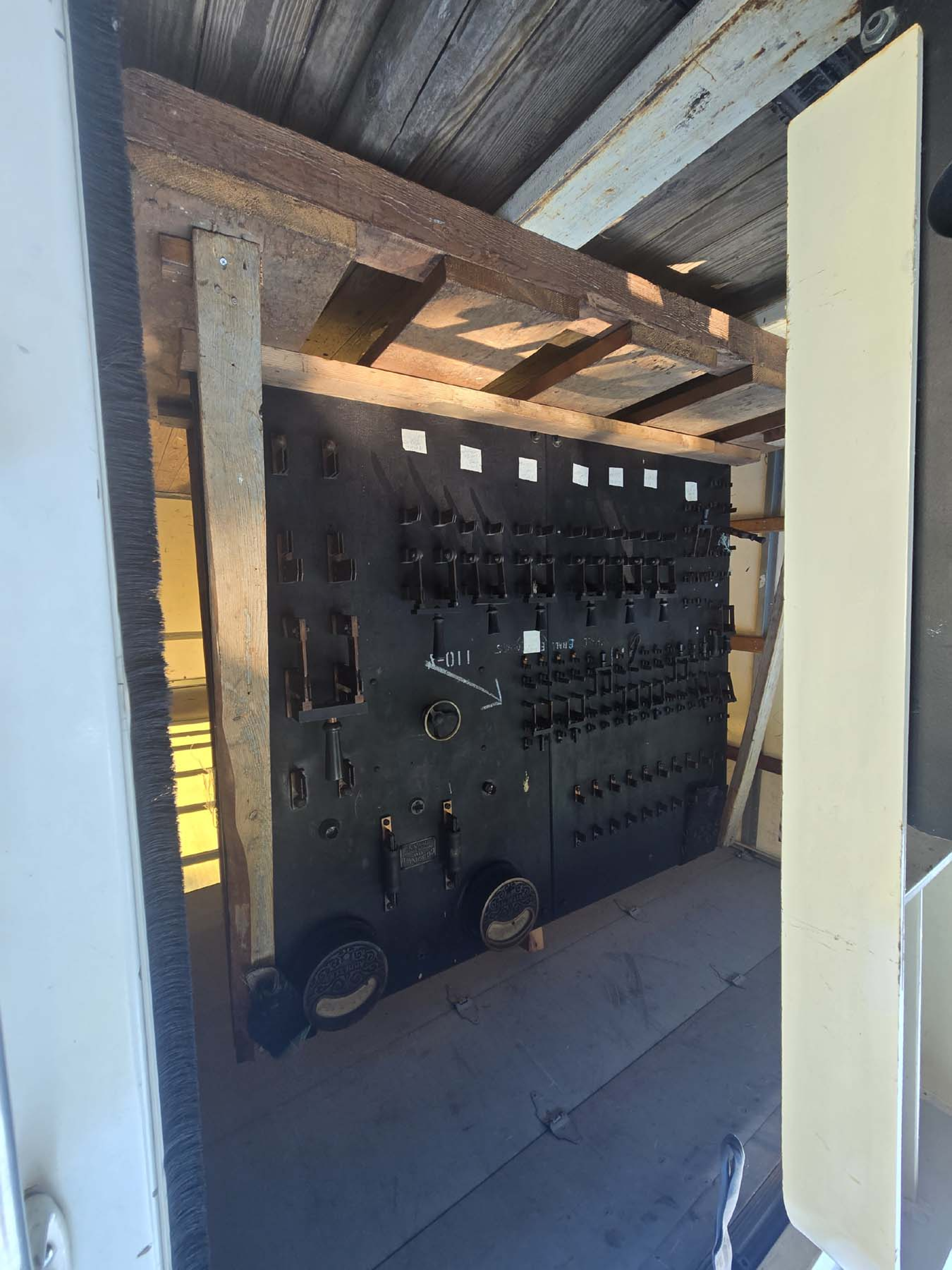
T. R. Emmons Frank [illegible] Forster Charles P. Steinmetz J. R. Nowell.

J. H. [illegible]



Charles P. Steinme

Yale
947752
Budget


110-5

S.I.T.E.S.
144
S.I.T.E.S.
144
DO NOT
DROP
"TOO DUMB FOR NY
TOO UGLY FOR LA"
KW

S.I.T.E.S.
144
BOX 11 OF
14 BOXES
W.37 L.49 H.45 WT. 222 lbs.
10688384

S.I.T.E.S.
144
DO NOT
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S.I.T.E.S.
144
DO NOT
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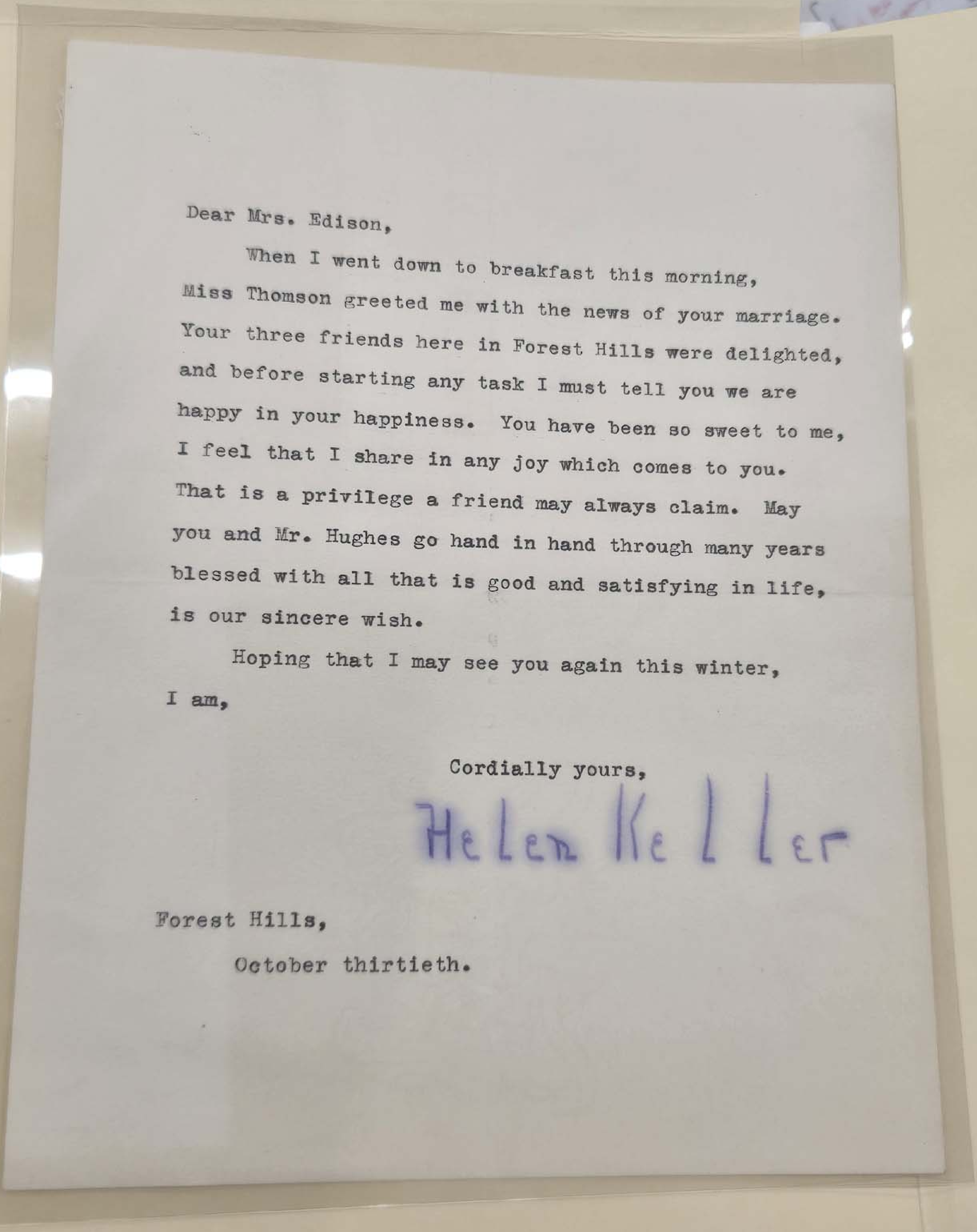


Dear Mrs. Edison,

When I went down to breakfast this morning, Miss Thomson greeted me with the news of your marriage. Your three friends here in Forest Hills were delighted, and before starting any task I must tell you we are happy in your happiness. You have been so sweet to me, I feel that I share in any joy which comes to you. That is a privilege a friend may always claim. May you and Mr. Hughes go hand in hand through many years blessed with all that is good and satisfying in life, is our sincere wish.

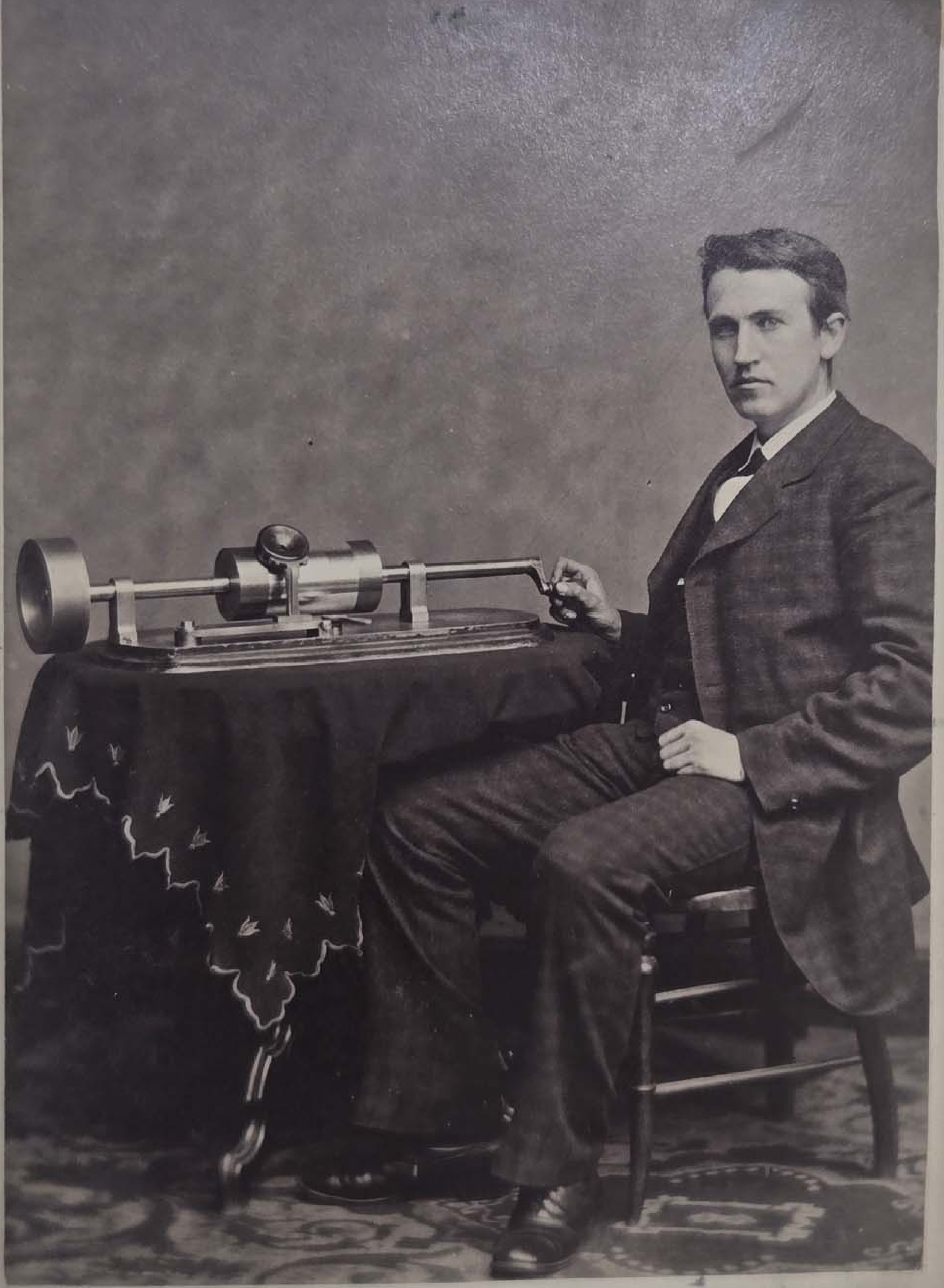
Hoping that I may see you again this winter, I am,

Cordially yours,

Helen Keller

Forest Hills,

October thirtieth.

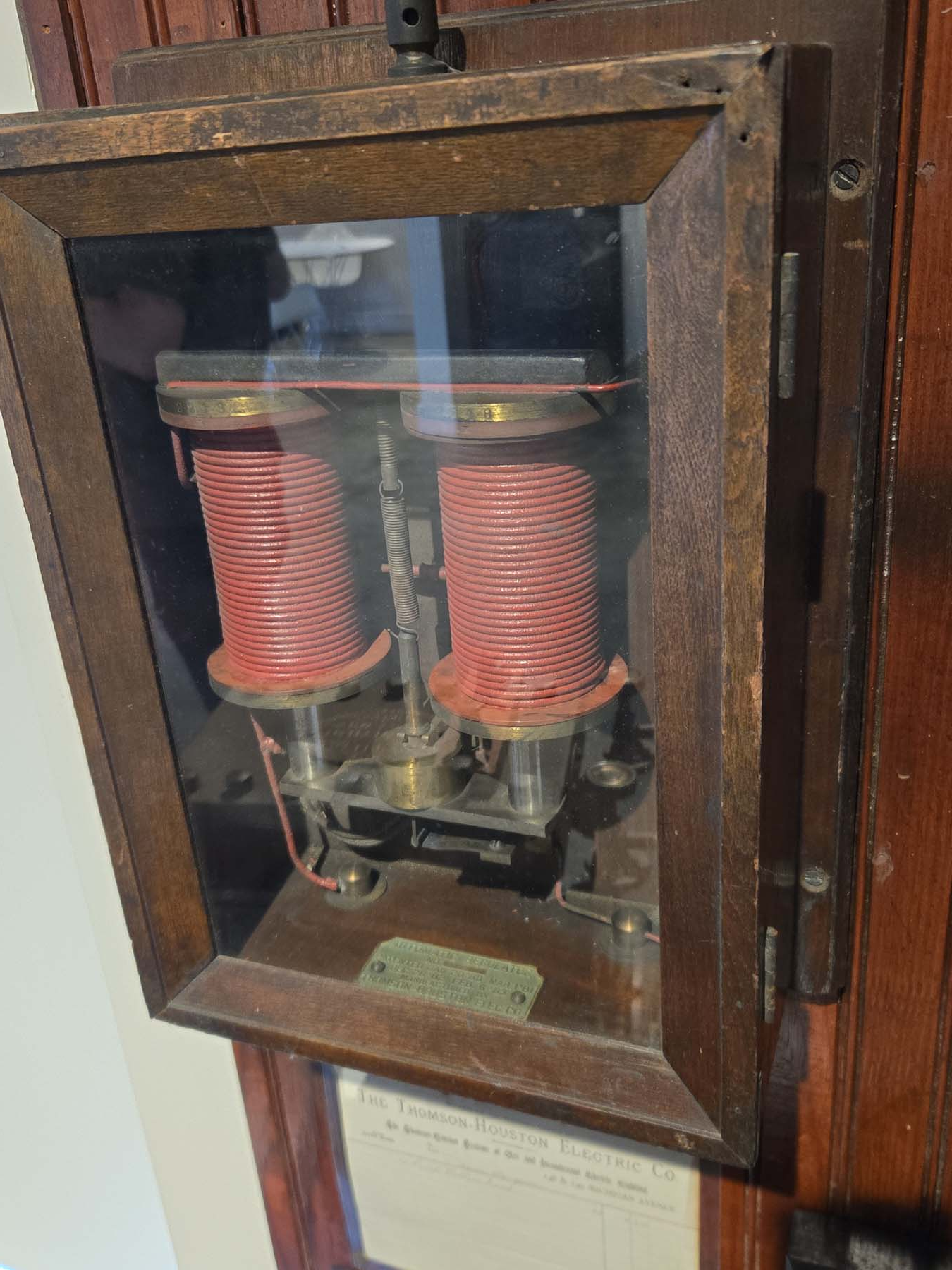


PROF. T. A. EDISON,

And his Speaking Phonograph, before National Academy of Science

BRADY APRIL, 1878. WASHINGTON, D. C.

[COPYRIGHTED BY M. B. BRADY, 1878.]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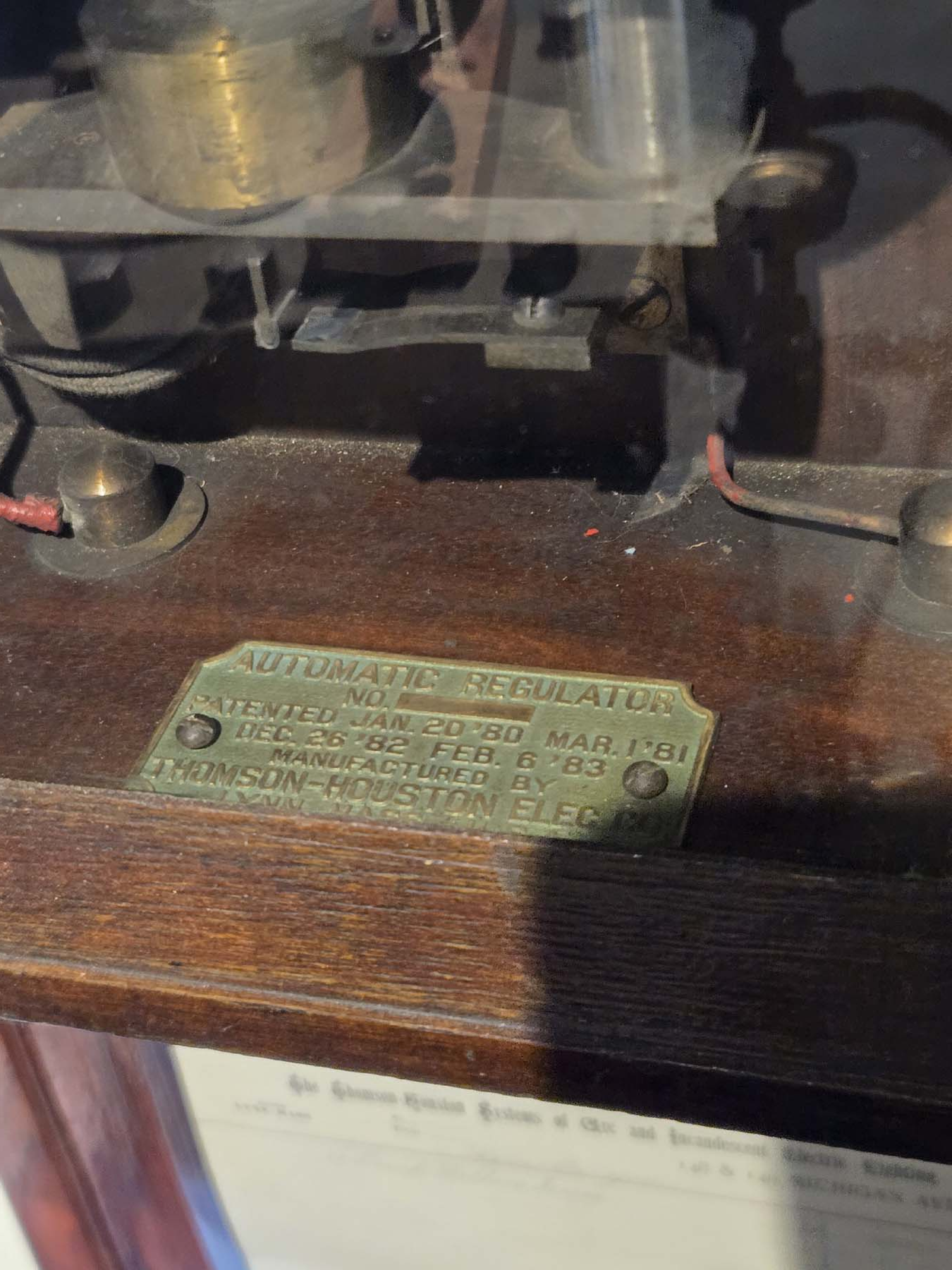
THE THOMSON-HOUSTON ELECTRIC CO


AUTOMATIC REGULATOR
NO.
PATENTED JAN. 20 '80 MAR. 1 '81
DEC. 26 '82 FEB. 6 '83
MANUFACTURED BY
THOMSON-HOUSTON ELEC. CO.
LYNN MASS

S.I.T.E.S.
144
S.I.T.E.S.
144
S.I.T.E.S.
144

Yale
Yale
PC1419
10688384
CSS

Yale
Yale
Yale
PC1419
10688384
CSS
KENWORTH
DORSEY

S.I.T.E.S.
144

LIGHTS
S.I.T.E.S.
144
HDX
27G

Budget
Budget
Budget

EXIT
FIRE
S.I.T.E.S.
144
S.I.T.E.S.
144
GERMINATOR
JOIN THE EVO

RESEARCH &
EVELOPMENT
EXIT
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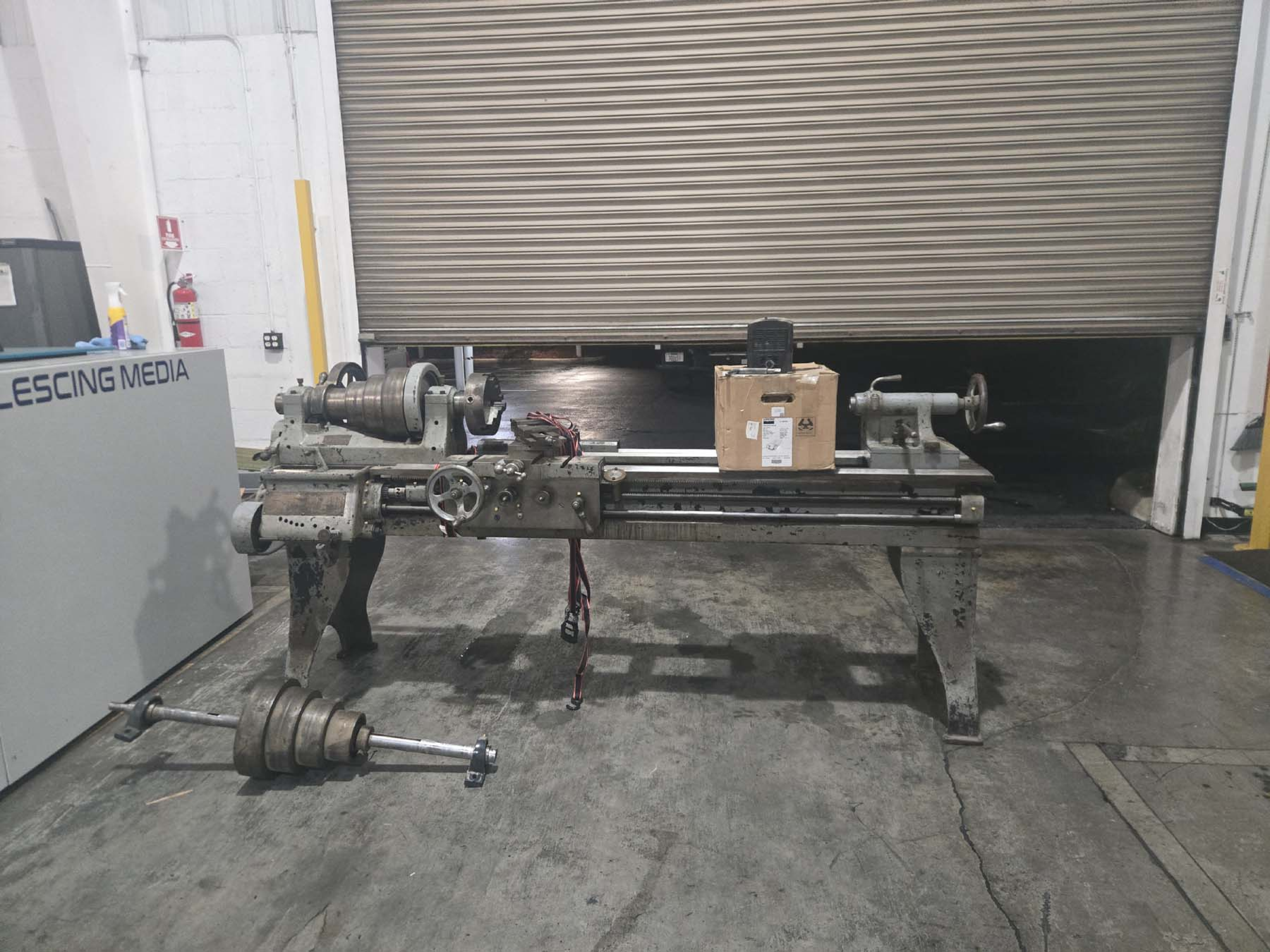
144
DO NOT
DROP
S.I.T.E.S.
144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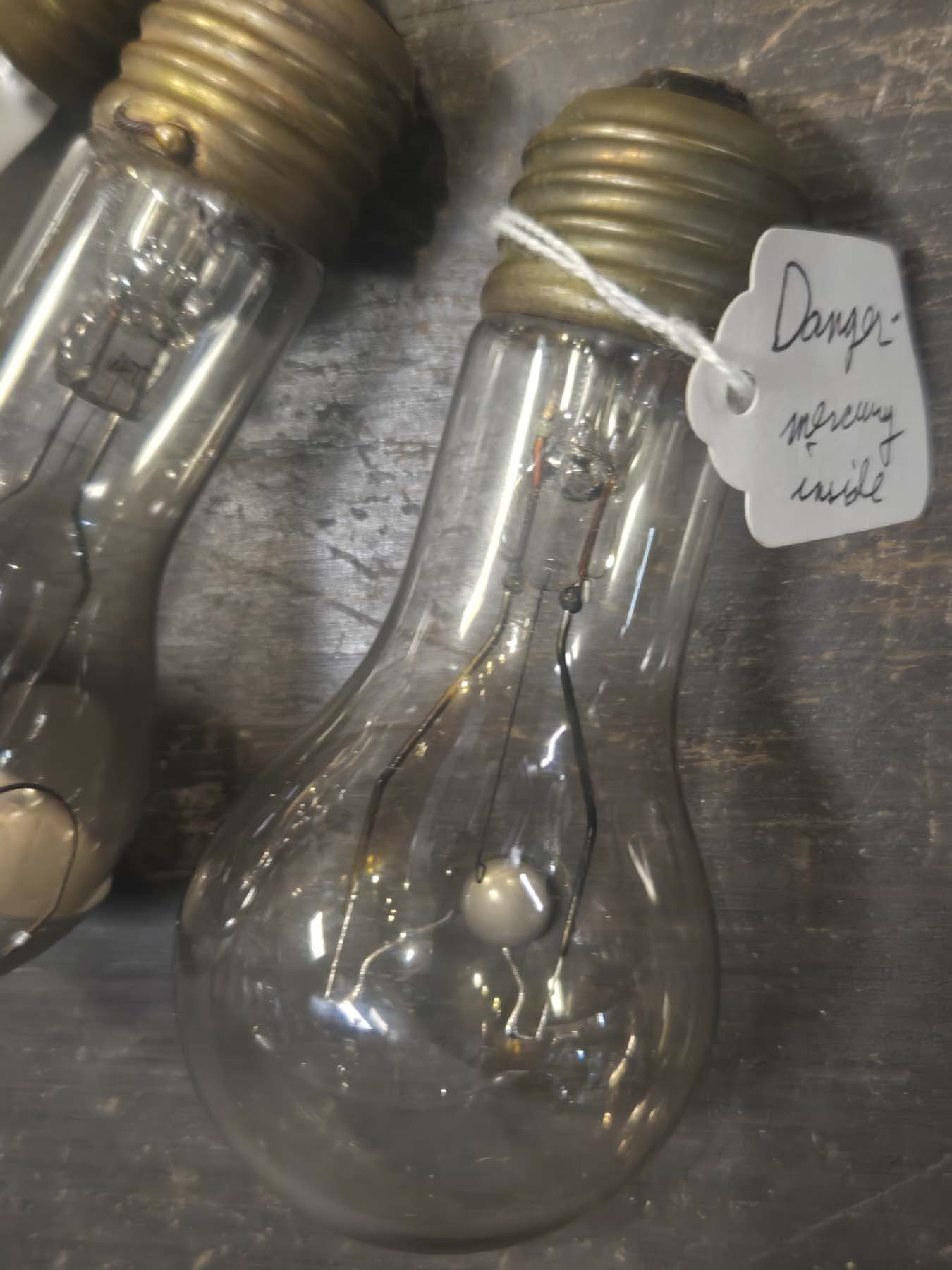
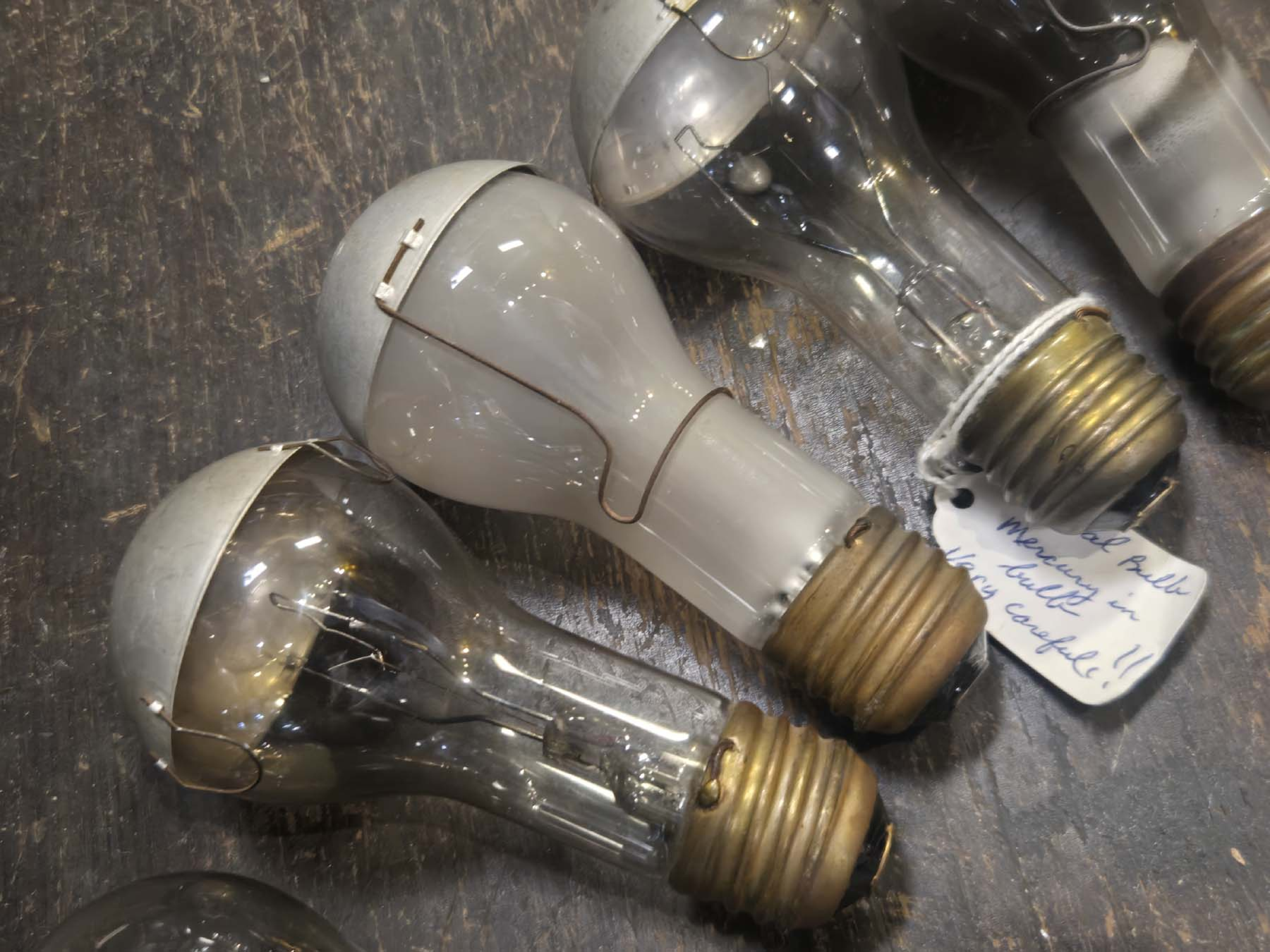
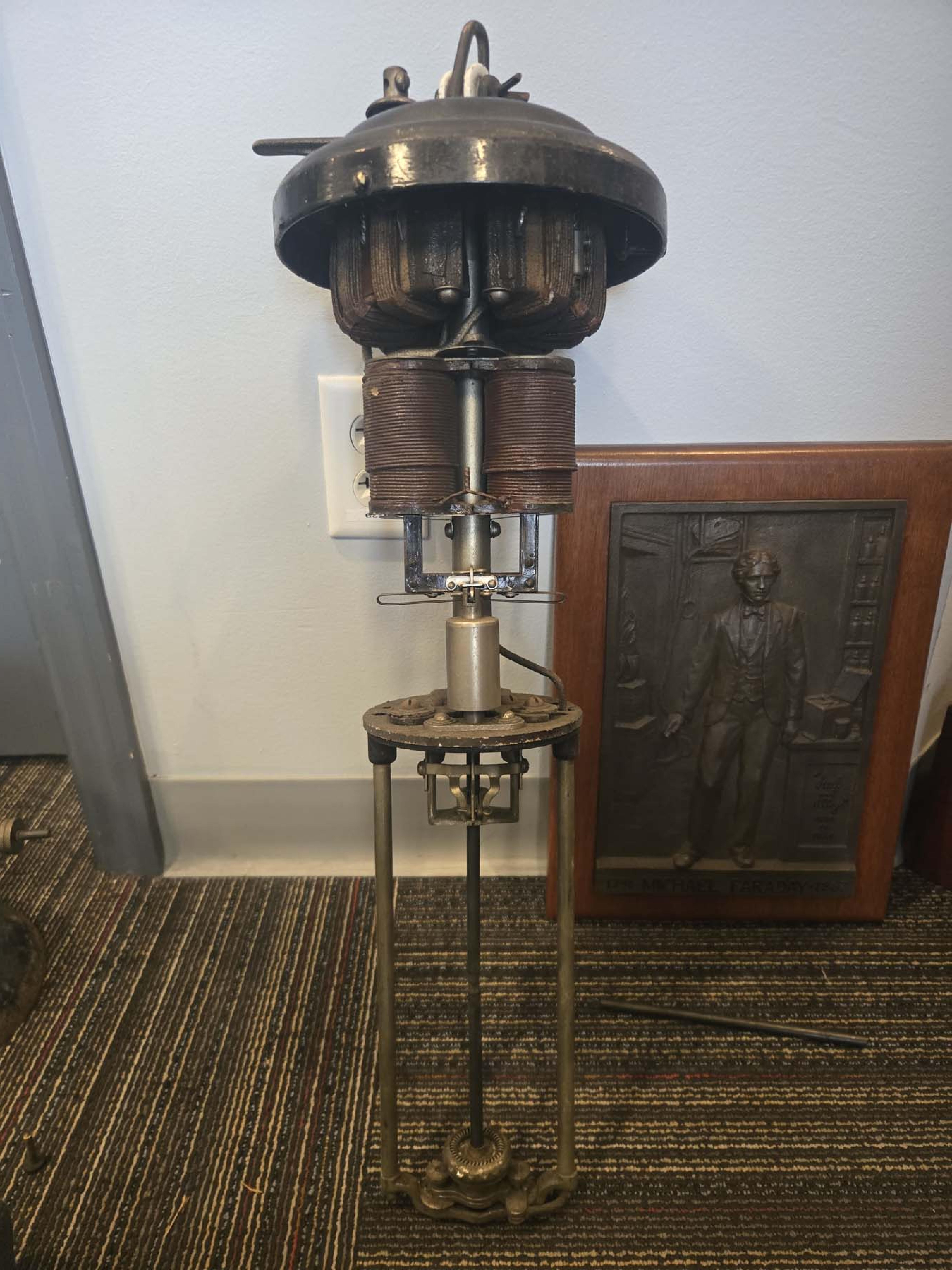
bulb
mercury
built in
Very careful!!


Danger-
mercury
inside


al Bulb
Mercury in
bulb
Very careful!!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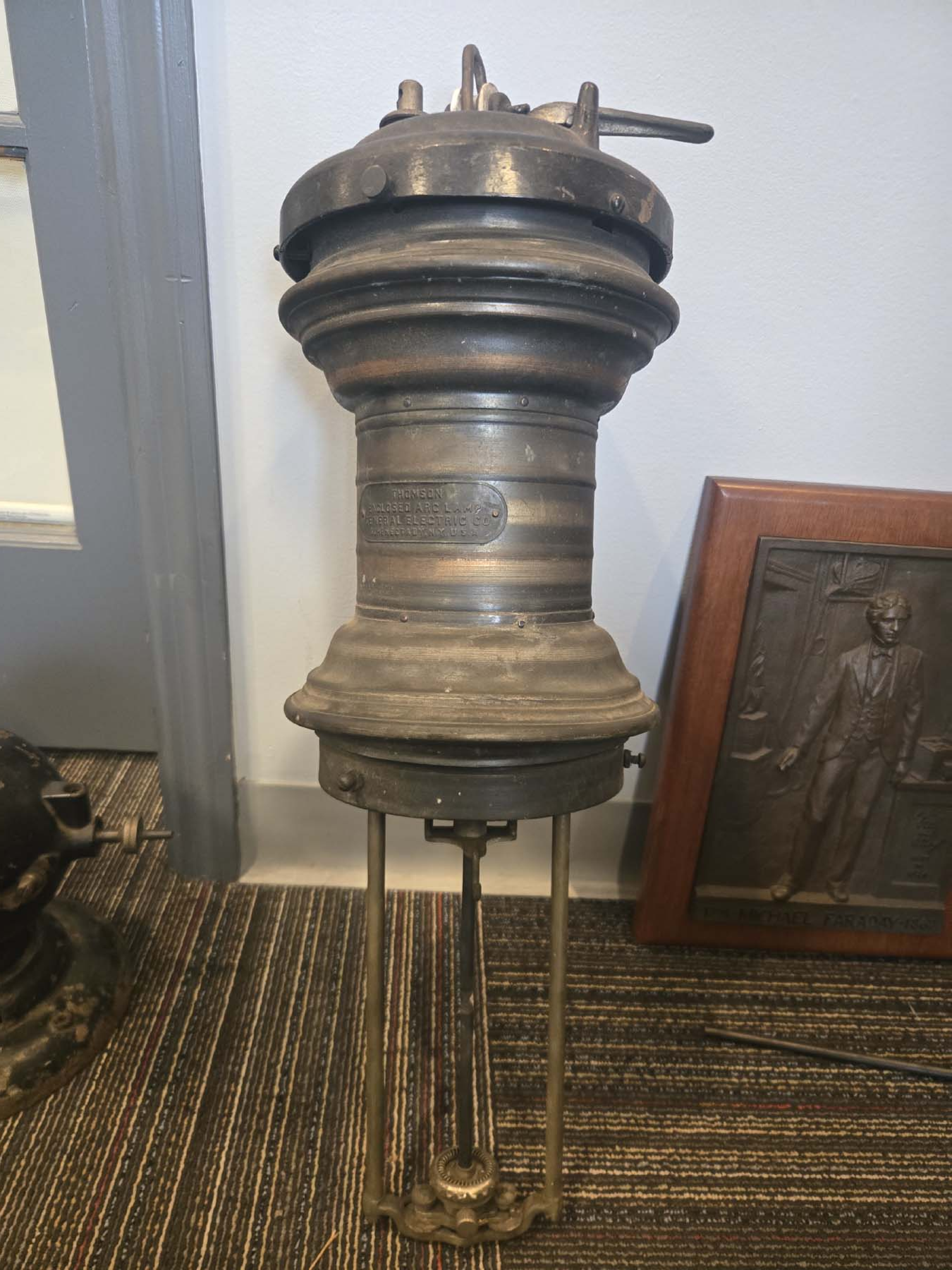
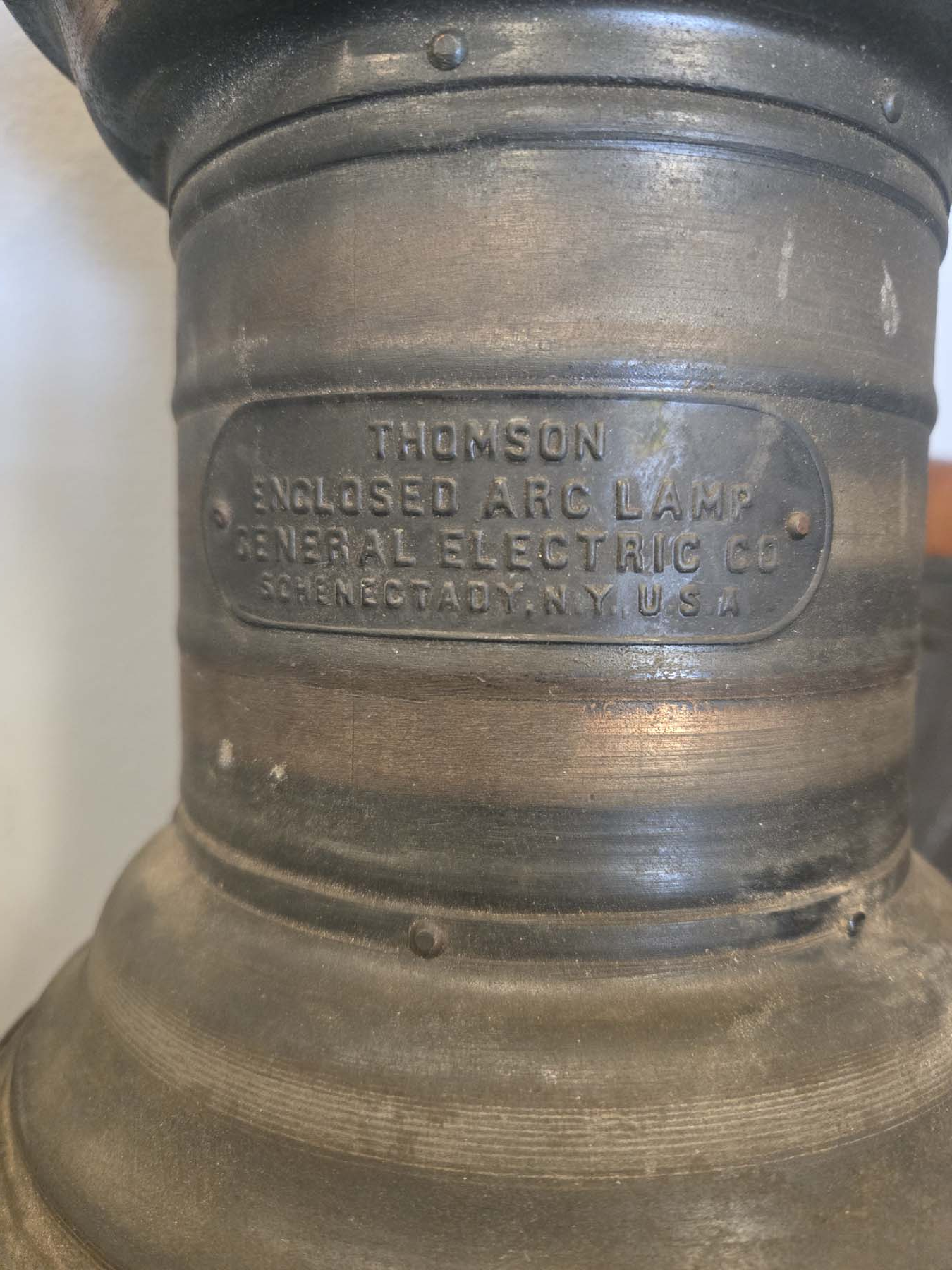

THOMSON
ENCLOSED ARC LAMP
GENERAL ELECTRIC CO
SCHENECTADY, N.Y. U.S.A.
MICHAEL FARADAY


THOMSON
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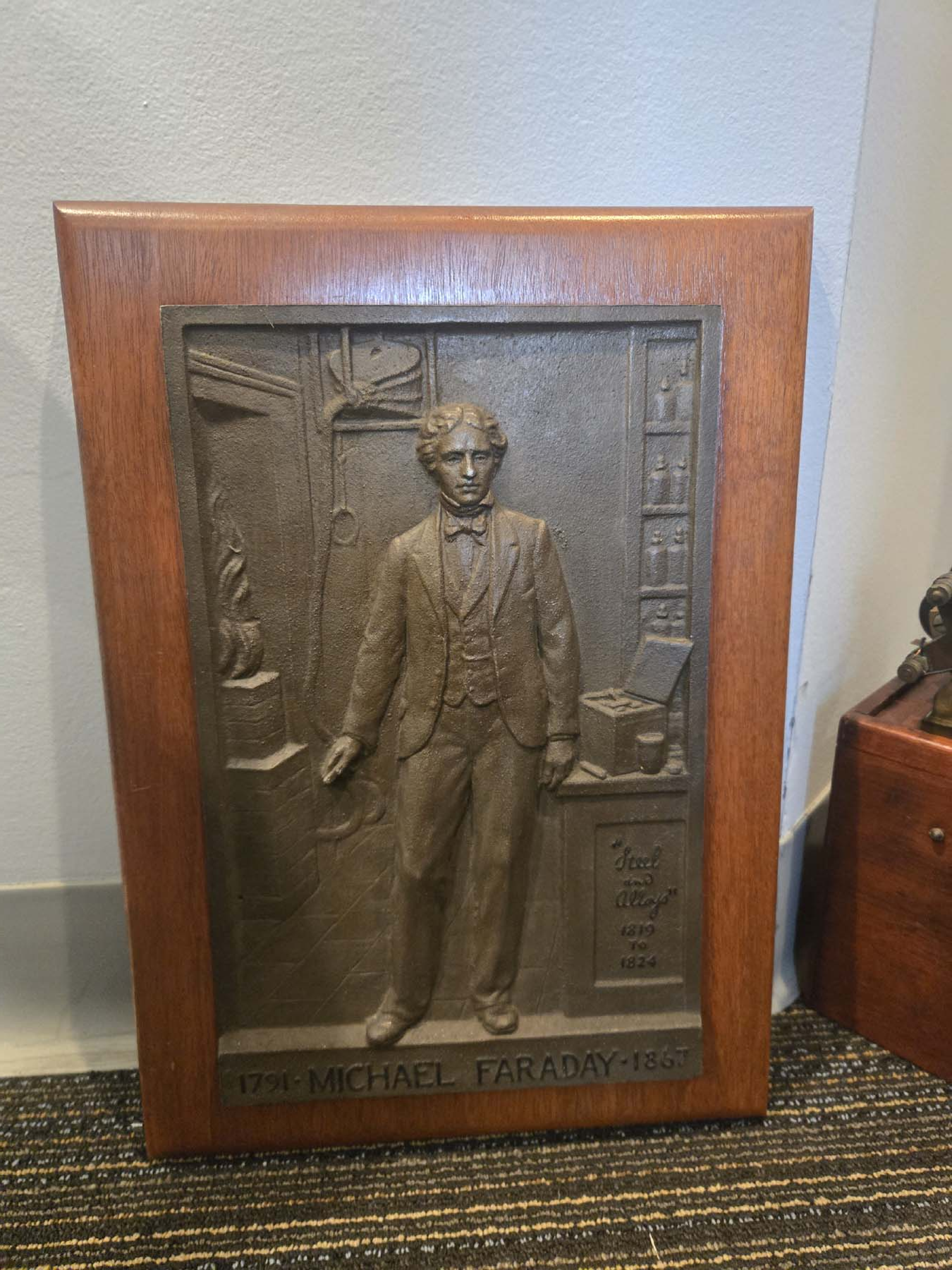
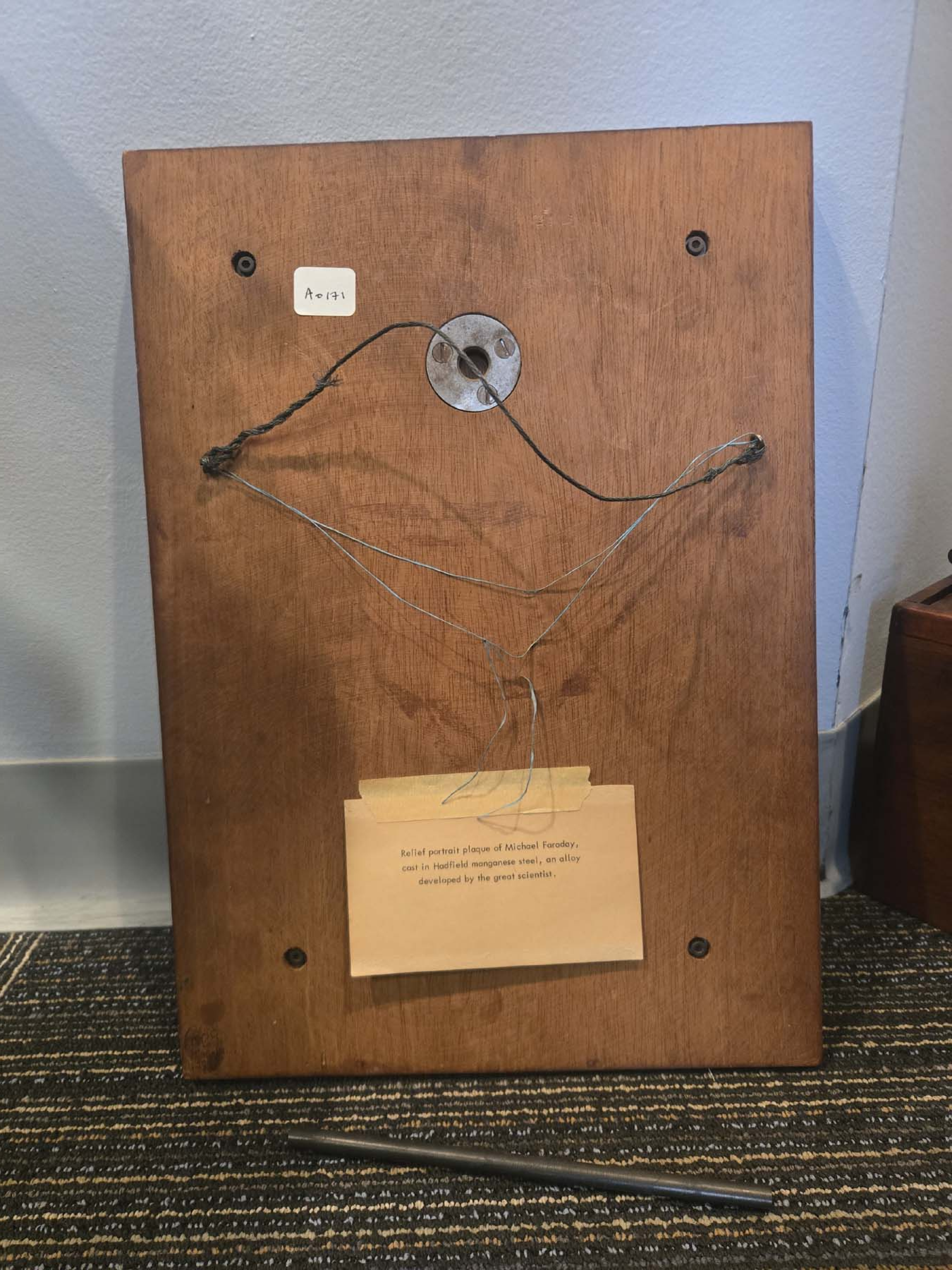
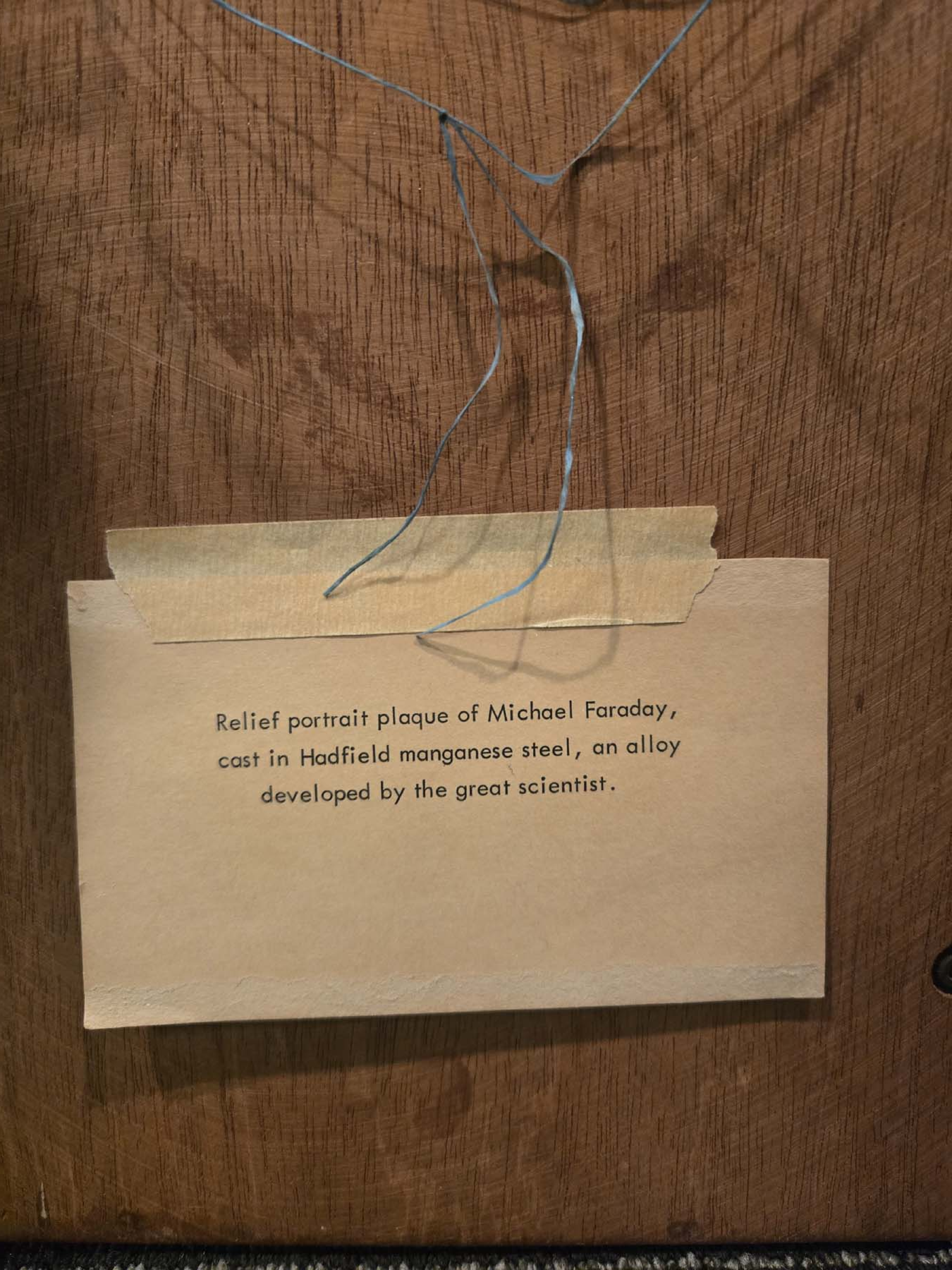
GENERAL ELECTRIC CO
SCHENECTADY, N.Y. U.S.A


"Steel and Alloys"
1819 to 1824
1791 · MICHAEL FARADAY · 1867

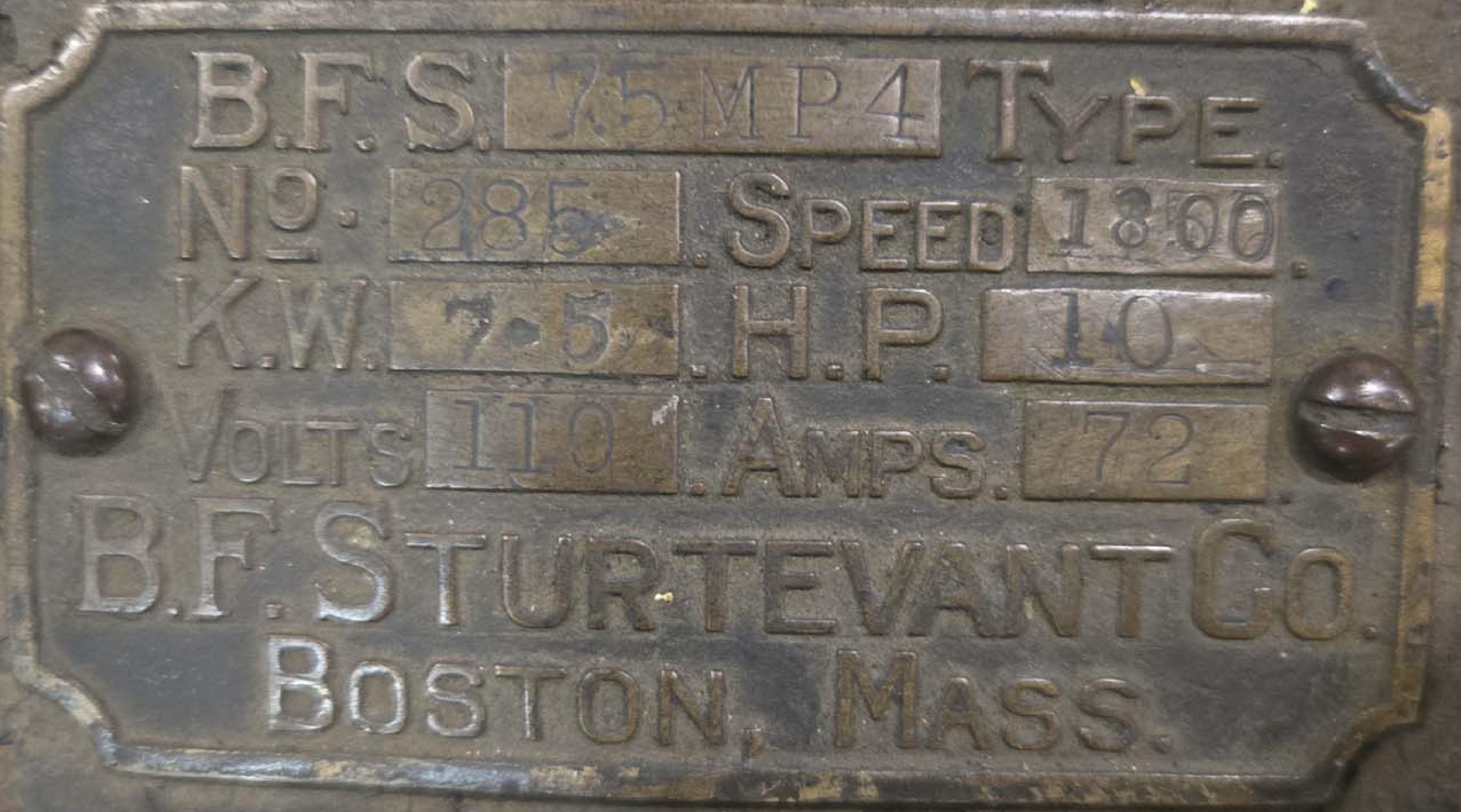


Relief portrait plaque of Michael Faraday,
cast in Hadfield manganese steel, an alloy
developed by the great scientist.



Relief portrait plaque of Michael Faraday,
cast in Hadfield manganese steel, an alloy
developed by the great scientist.

"Steel and Alloys"
1819 to 1824
1791 - MICHAEL FARADAY - 1867



B.F.S. 7.5 MP 4 TYPE.
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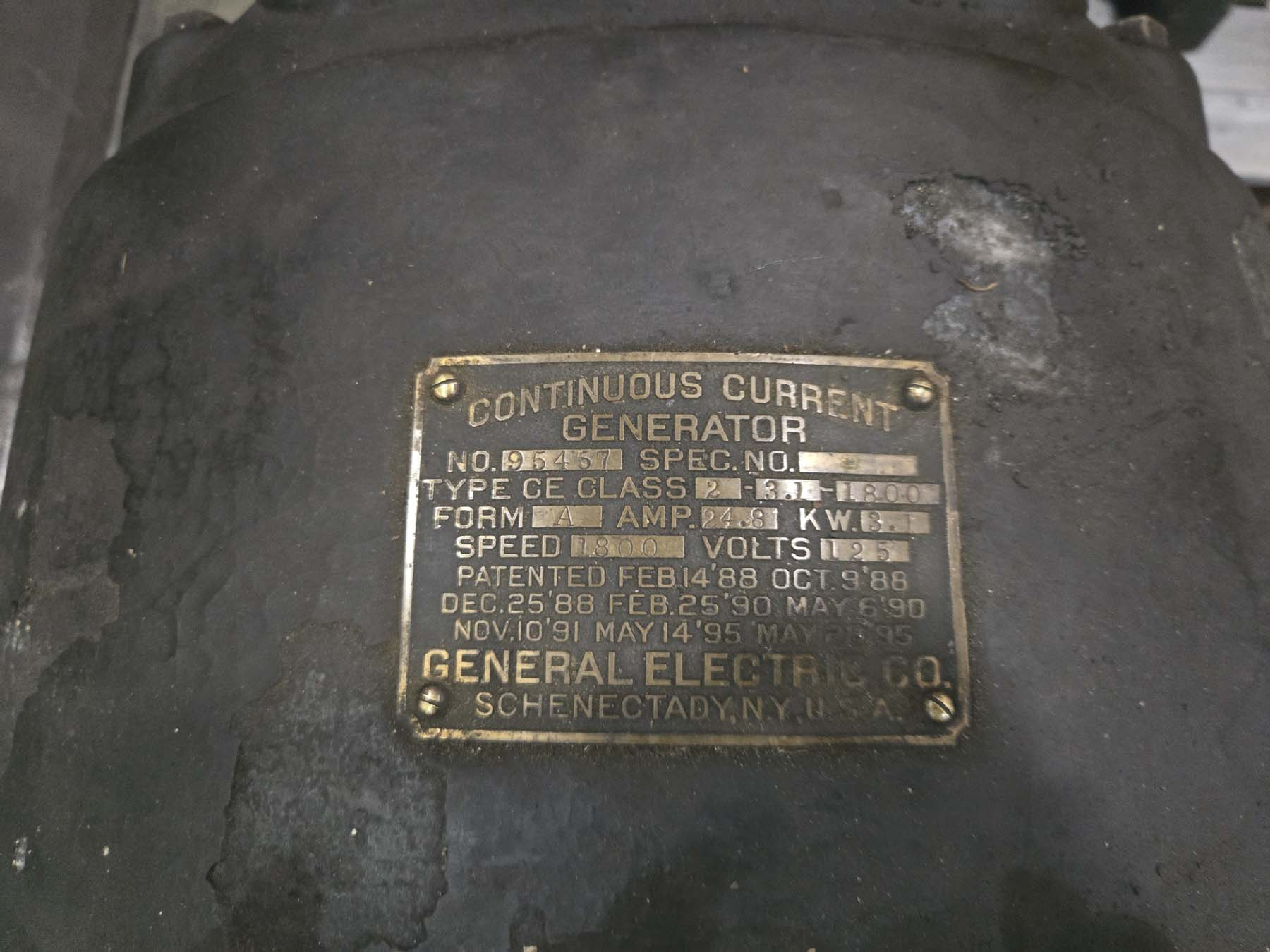
K.W. 7.5 . H.P. 10.
VOLTS 110 . AMPS. 72
B.F. STURTEVANT CO.
BOSTON, MASS.



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DEC. 25 '88 FEB. 25 '90 MAY 6 '90
NOV. 10 '91 MAY 14 '95 MAY [illegible] '95
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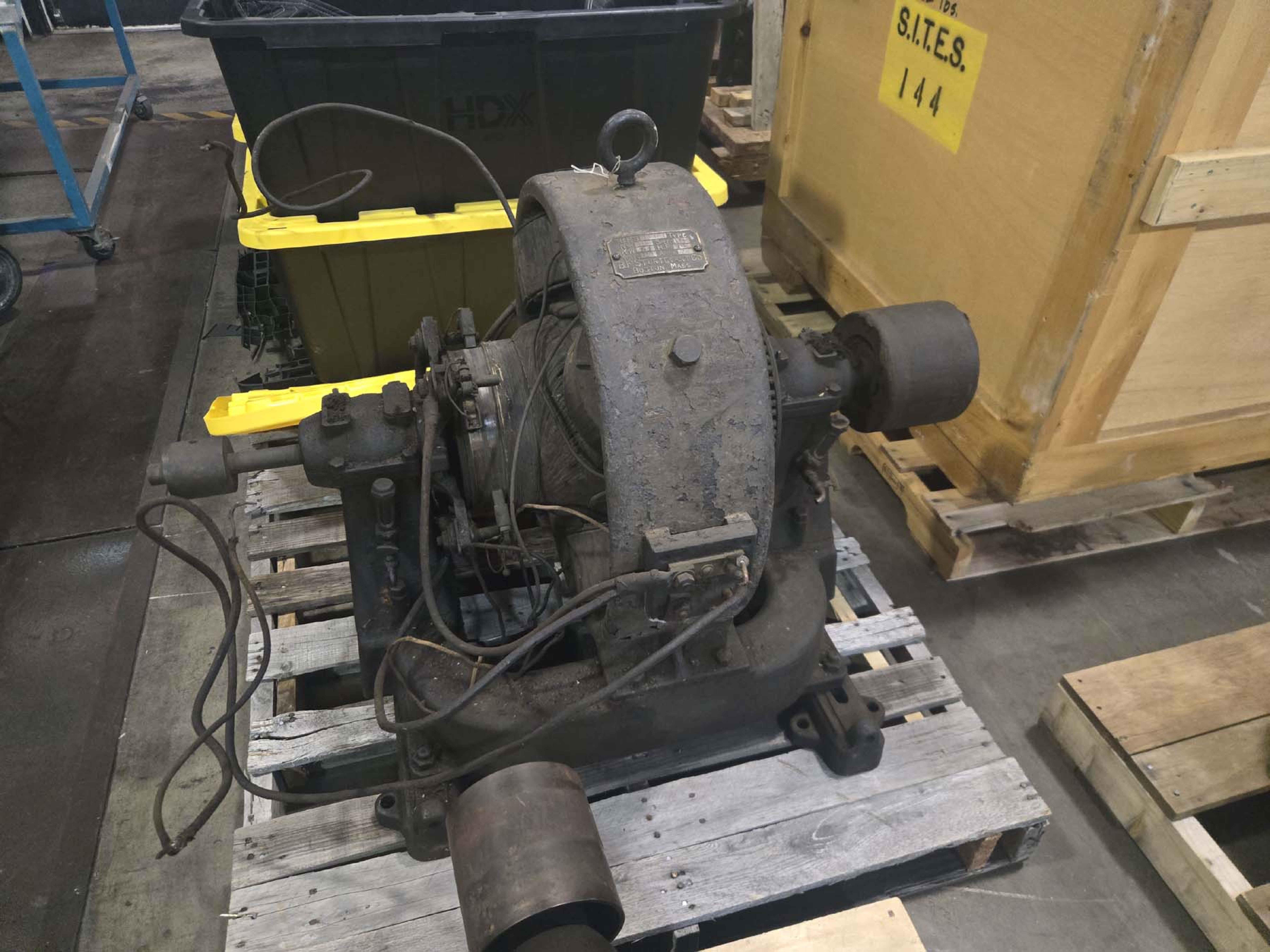
SCHENECTADY, N.Y. U.S.A.

S.I.T.E.S.
144


HDX
S.I.T.E.S.
144
TYPE
B.F. STURTEVANT CO
BOSTON, MASS.

RESEARCH & DEVELOPMENT
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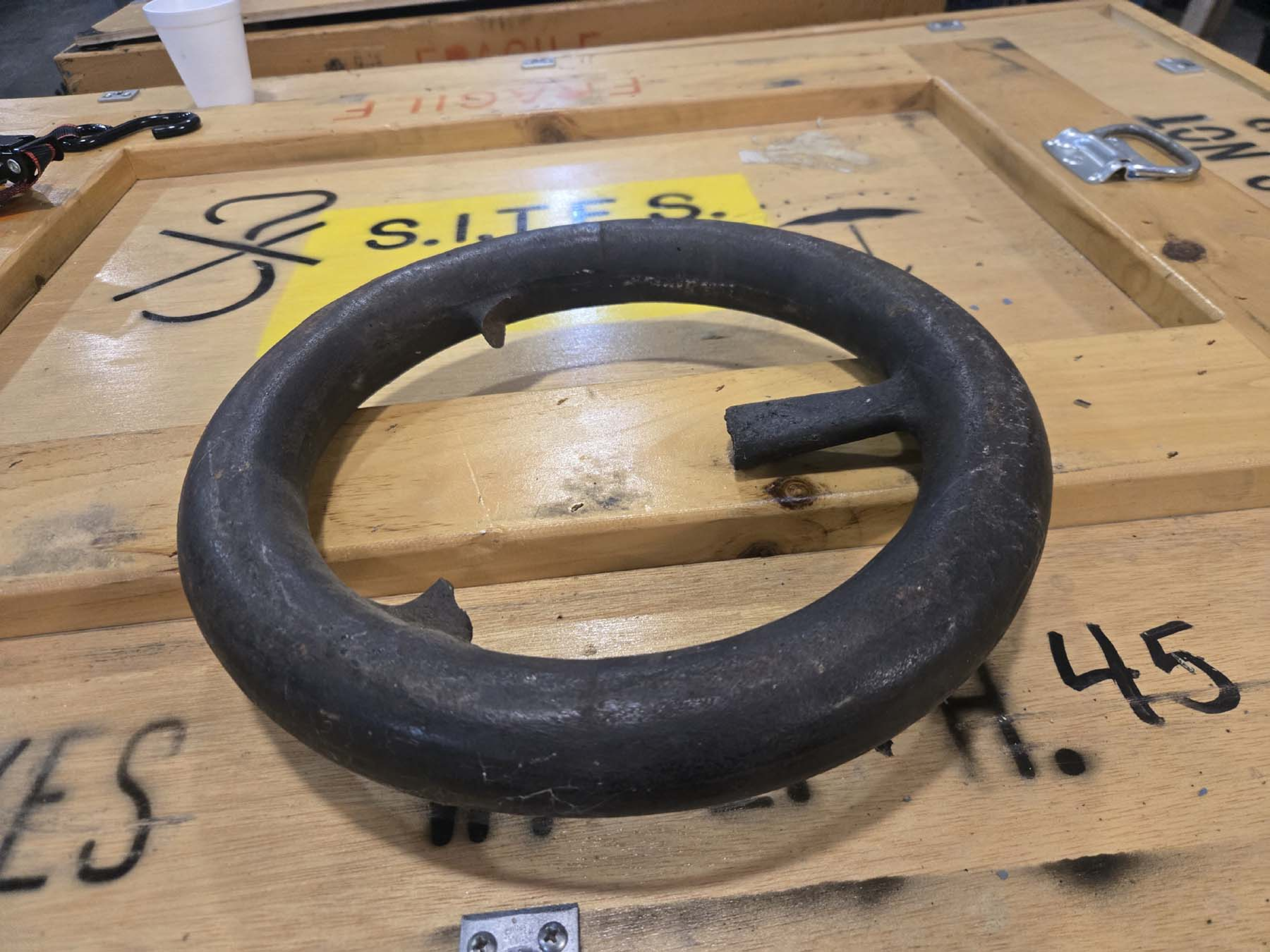
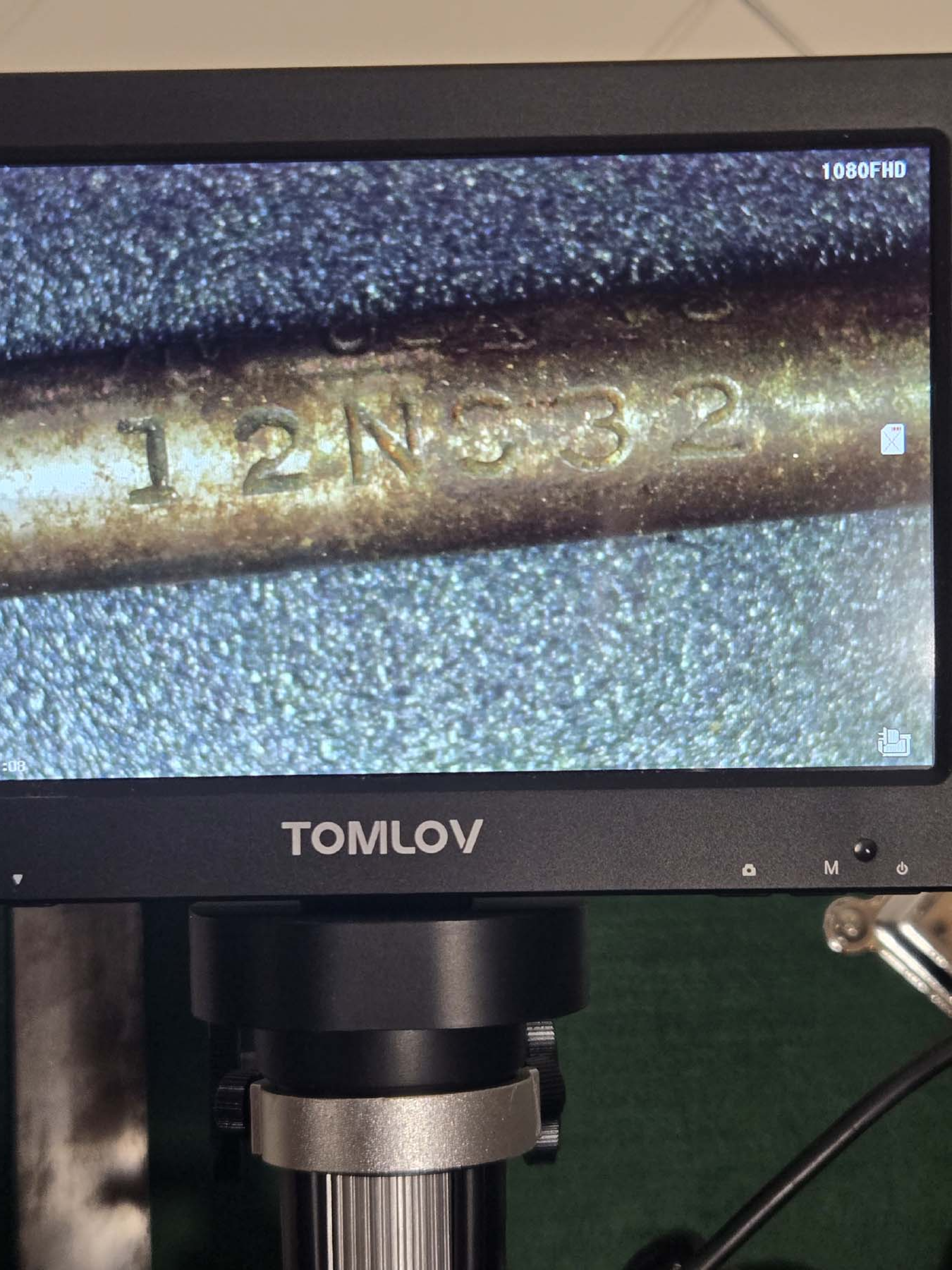
144
DO NOT DROP

S.I.T.E.S.
144



FRAGILE
S.I.T.E.S.
H. 45
ES

769
1107
2765
KILOWATTS
CYCLES
AMPERES
DEMAND METER
LINCOLN METER CO. LIMITED
500 1000 1500 2000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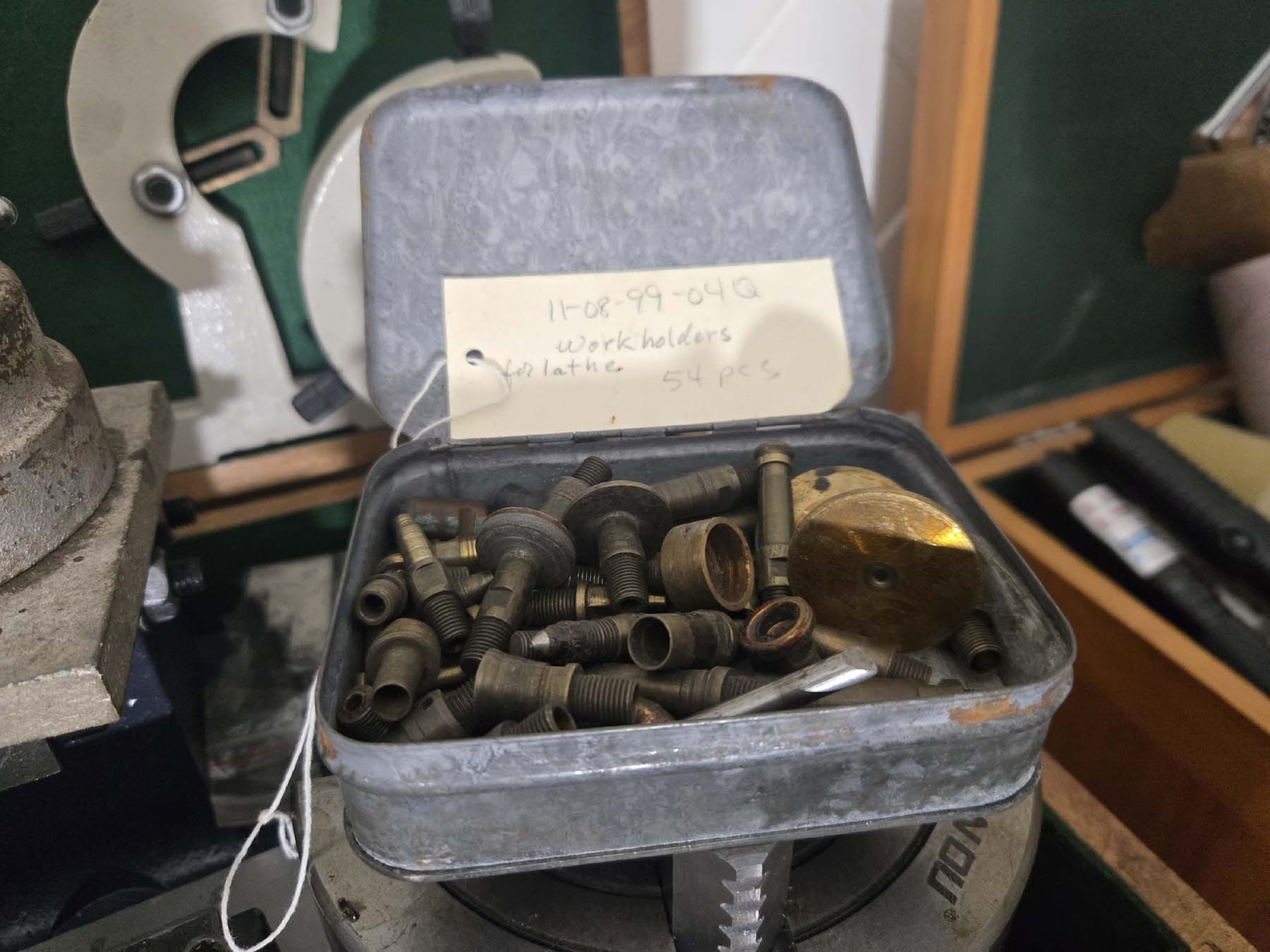
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for lathe
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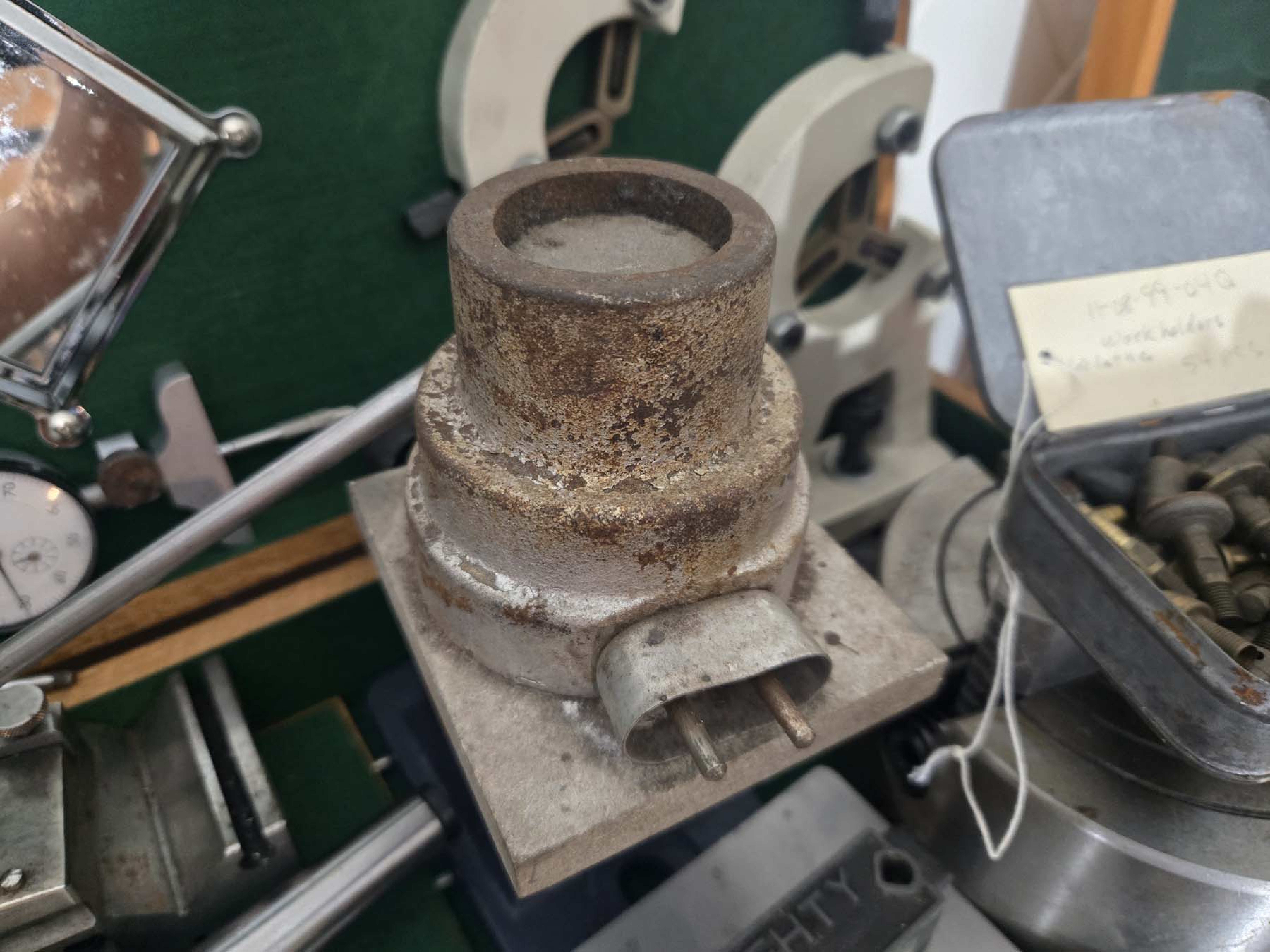
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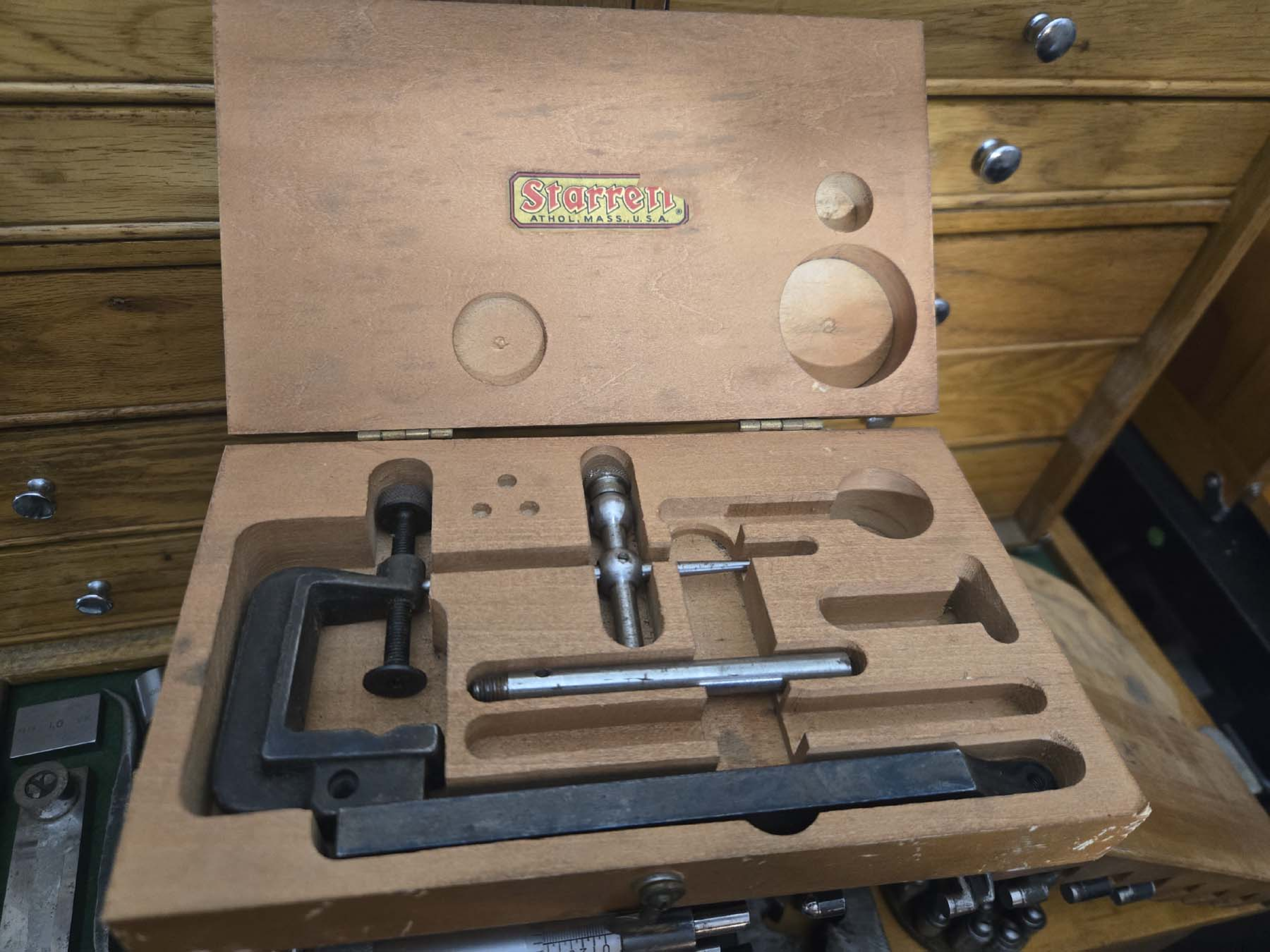
HTY

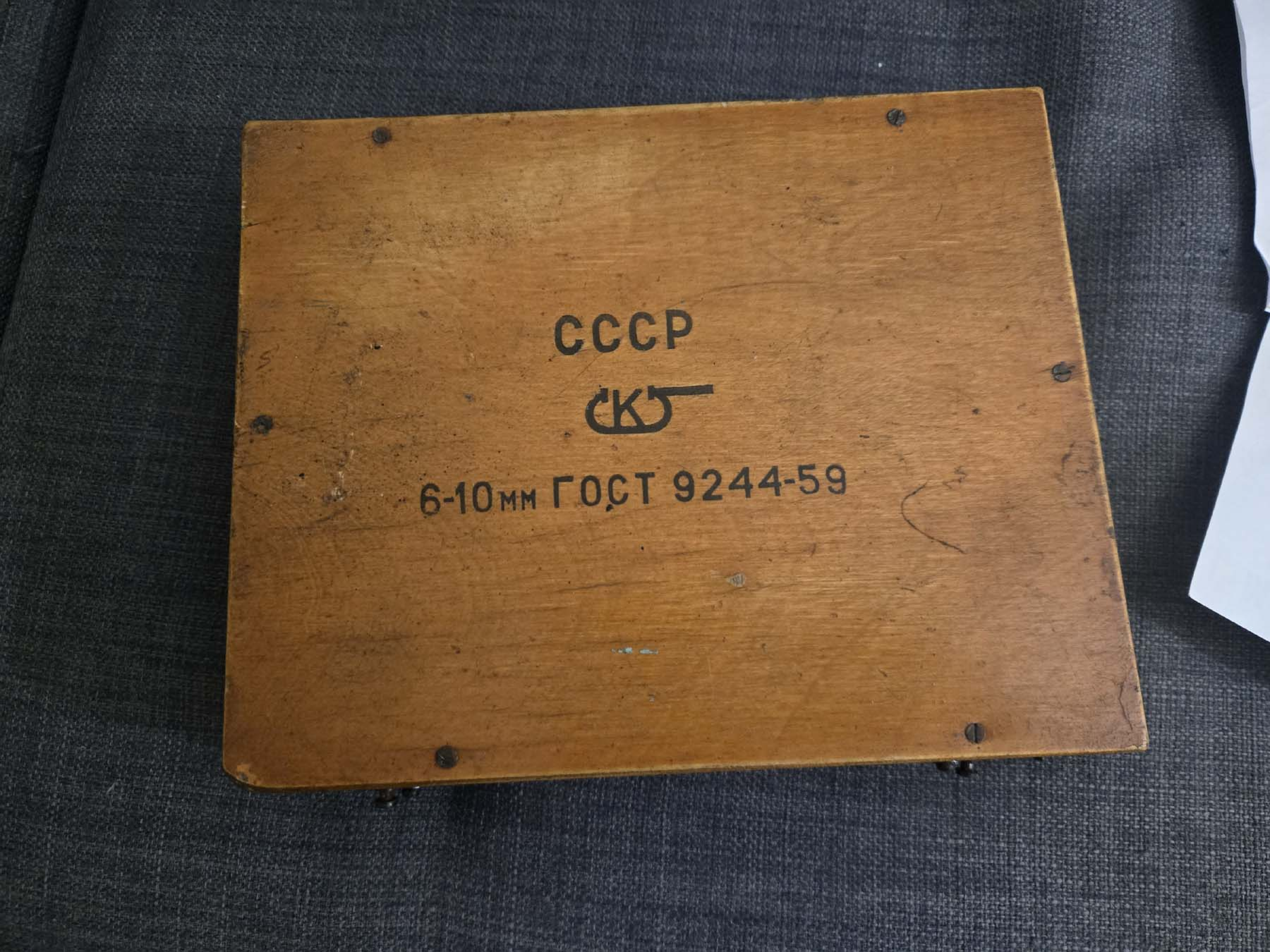
g Fluid
Brass
Zinc
Tin
Cobalt
Nickel


Starrett
ATHOL, MASS., U.S.A.

45° Thread Tool
WOODRUFF KEYSEAT CUTTER
R No. 3
HSS
506 B13
HEX NUTS
1/4 in

45° Thread
Too-ol.
KEYSEAT CUTTER
R No. 3

ORL
FL 334 0-02
UPS Ground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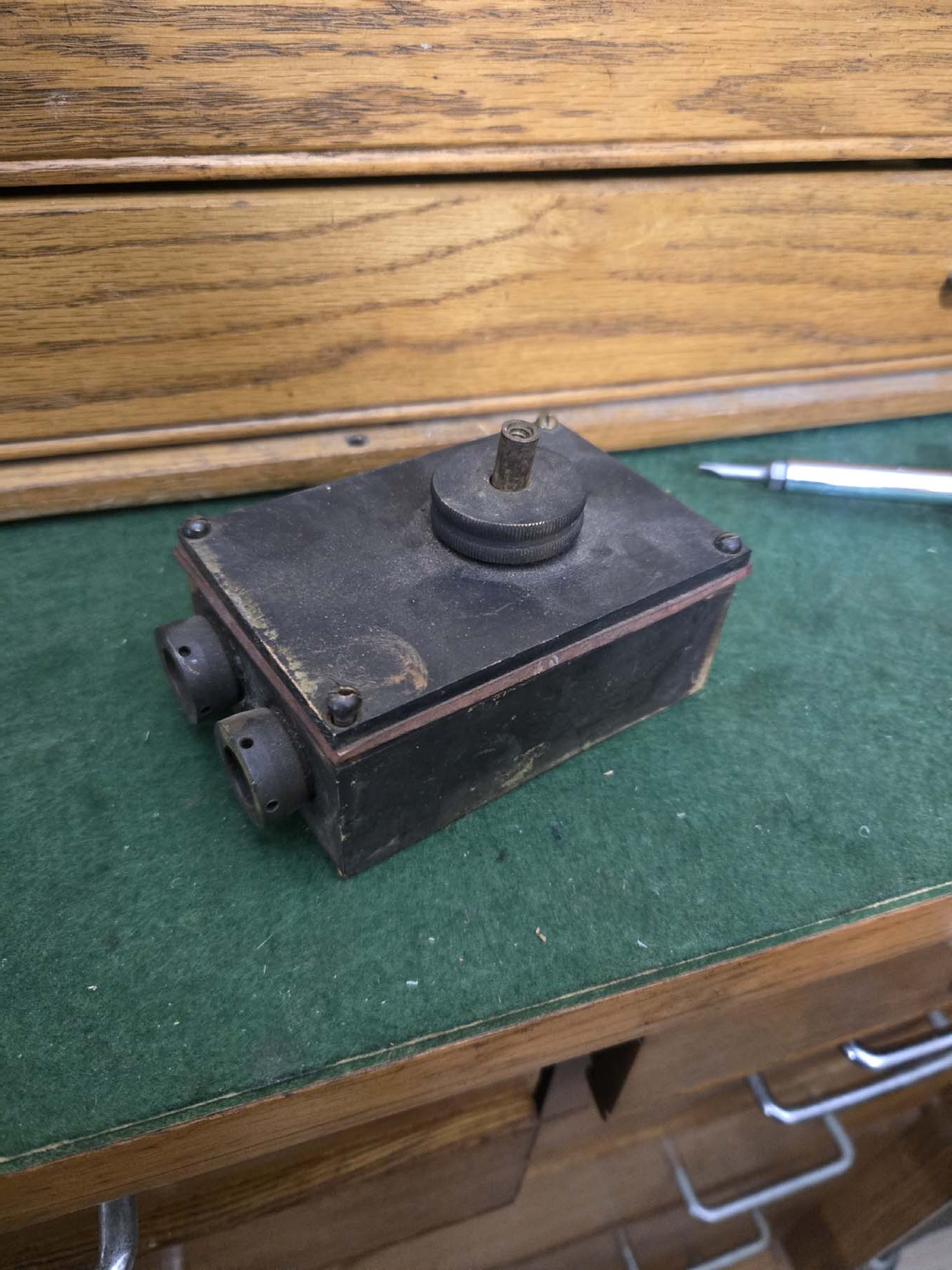

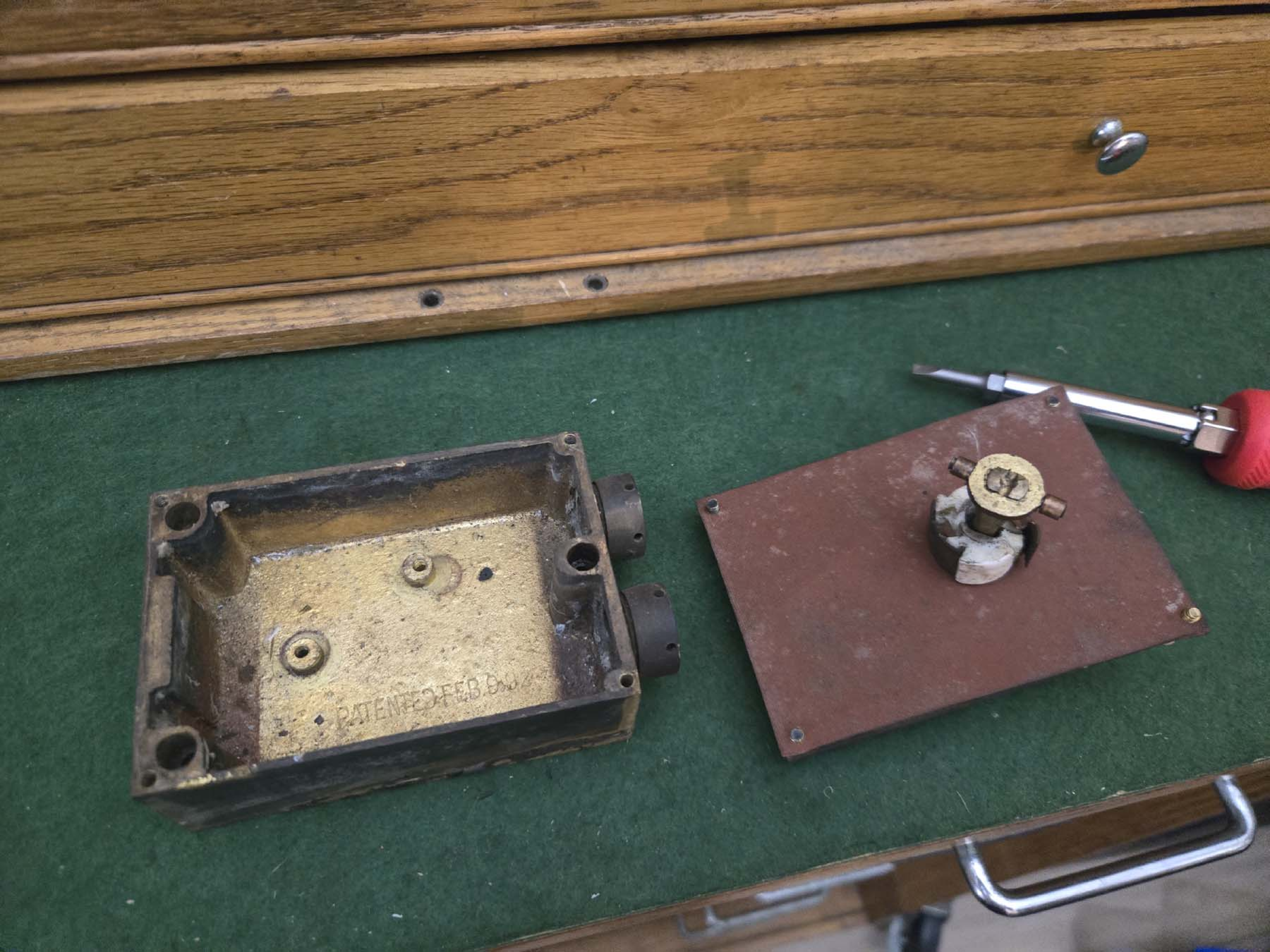
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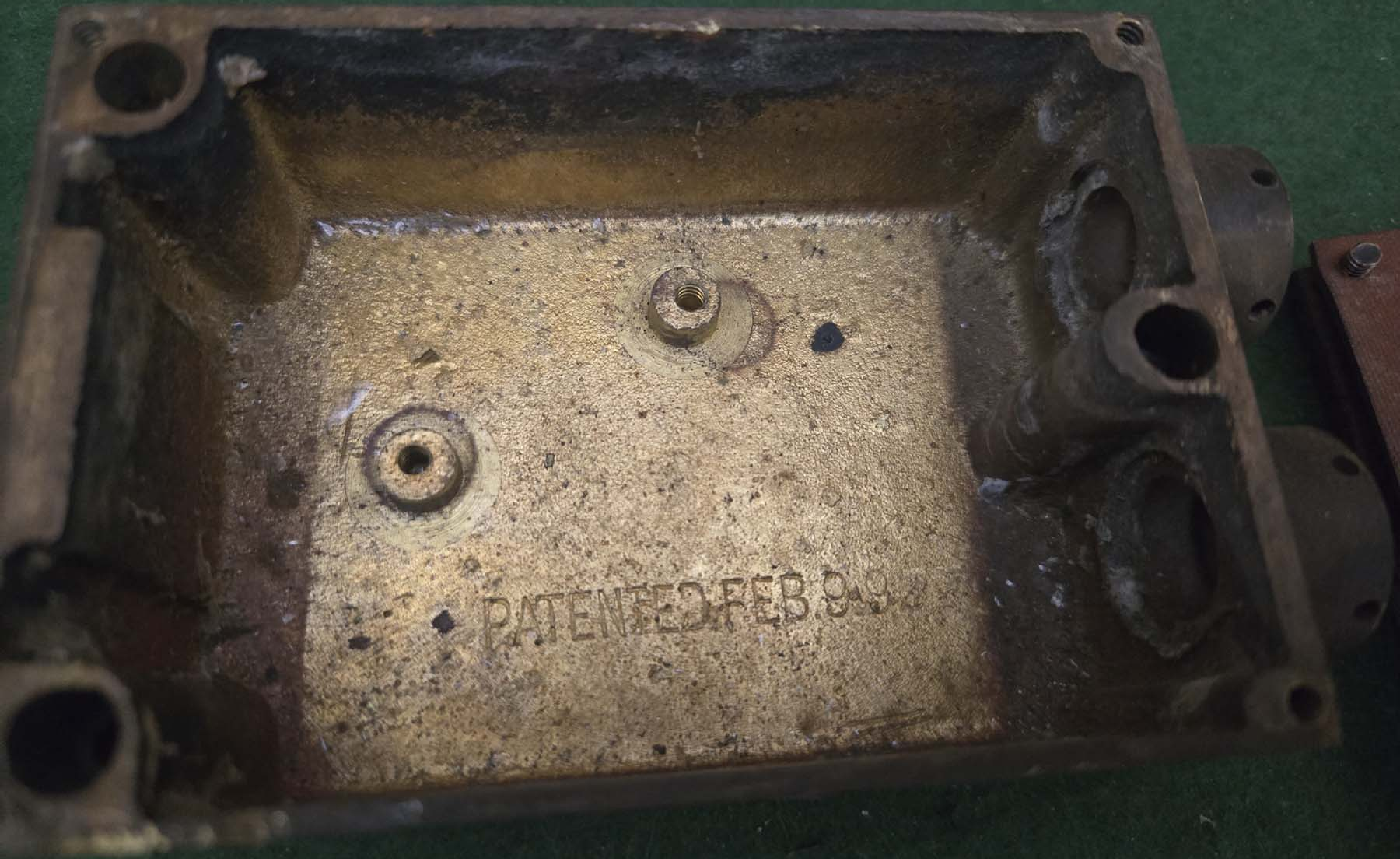
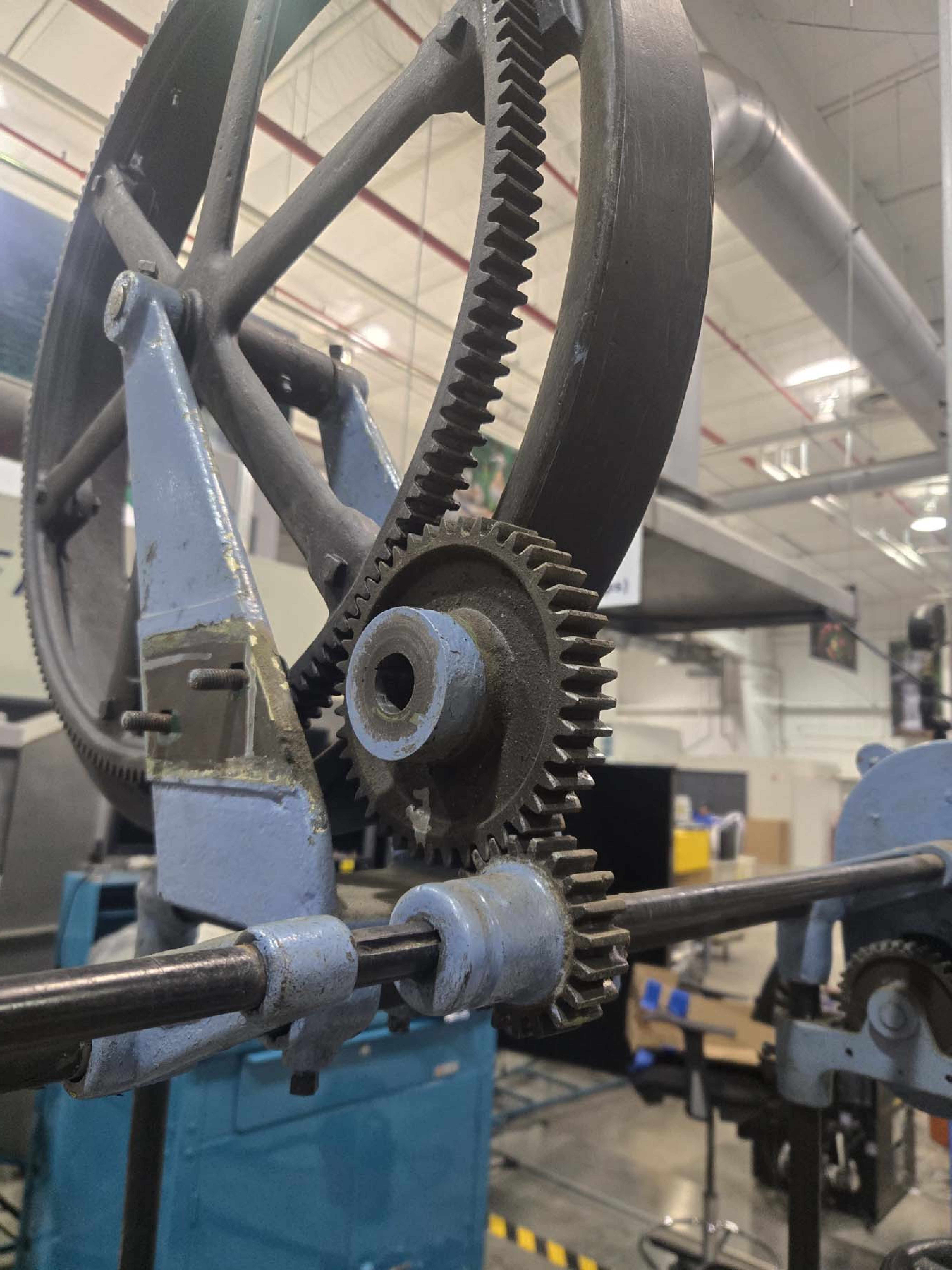
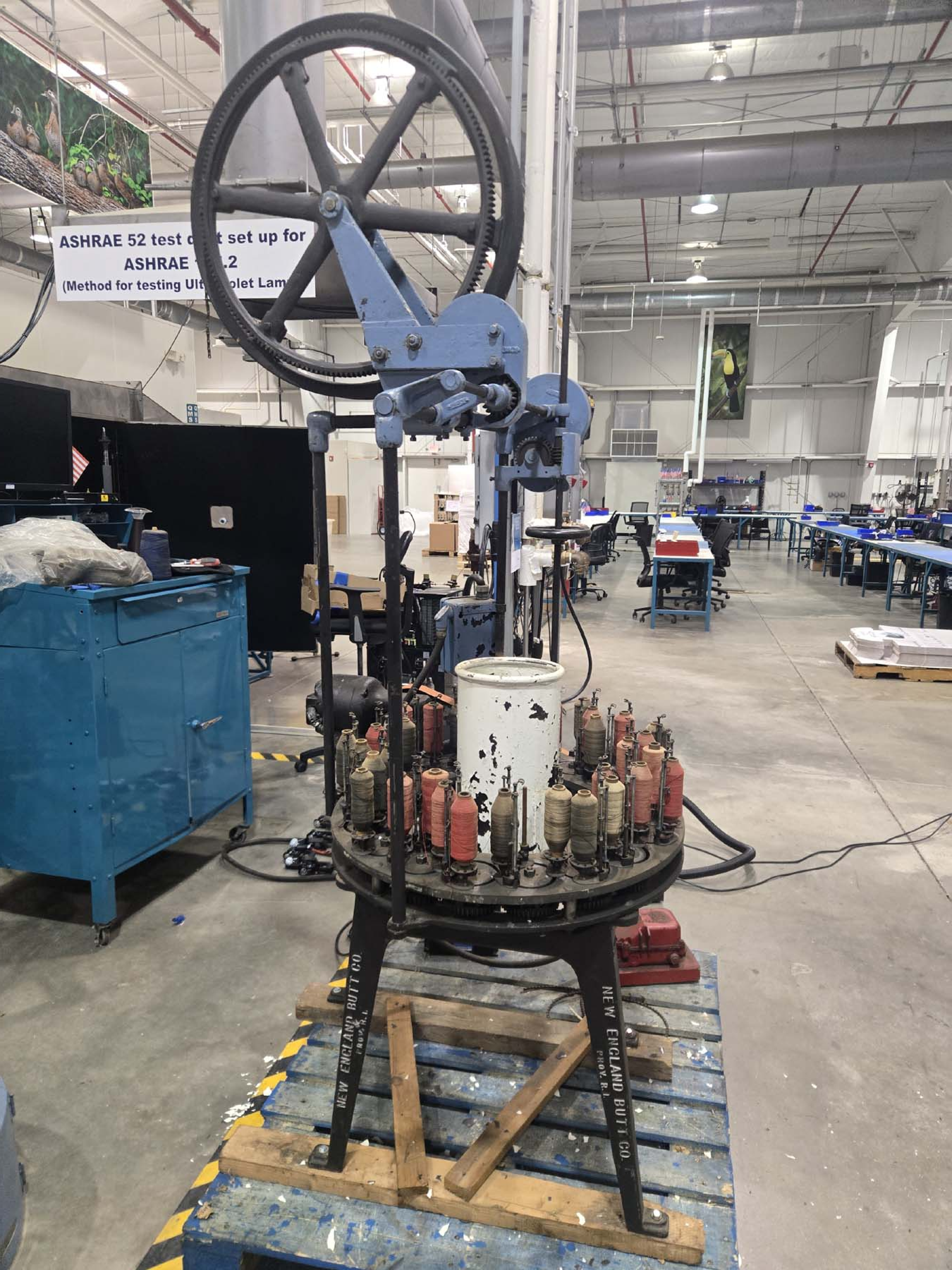
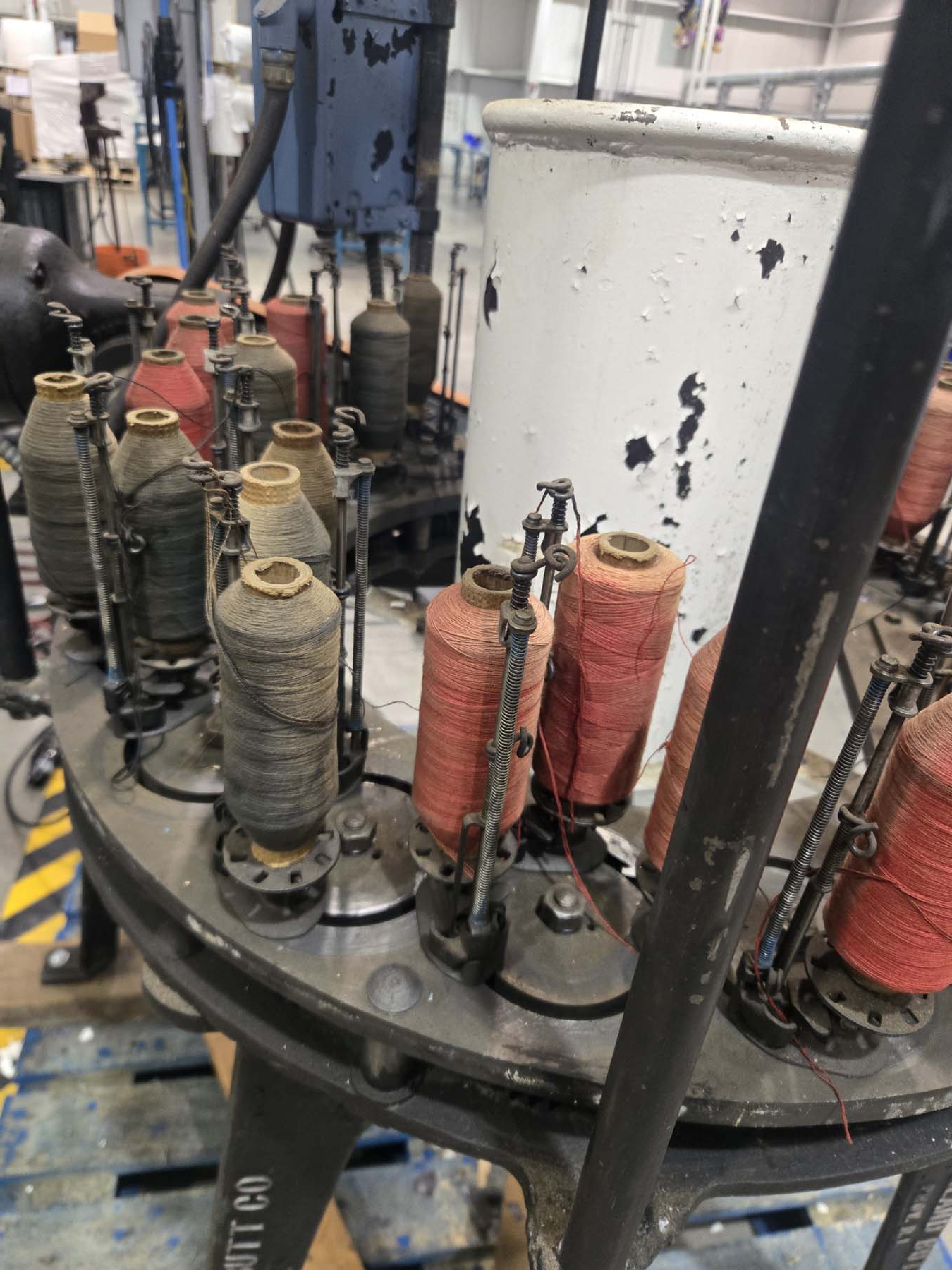
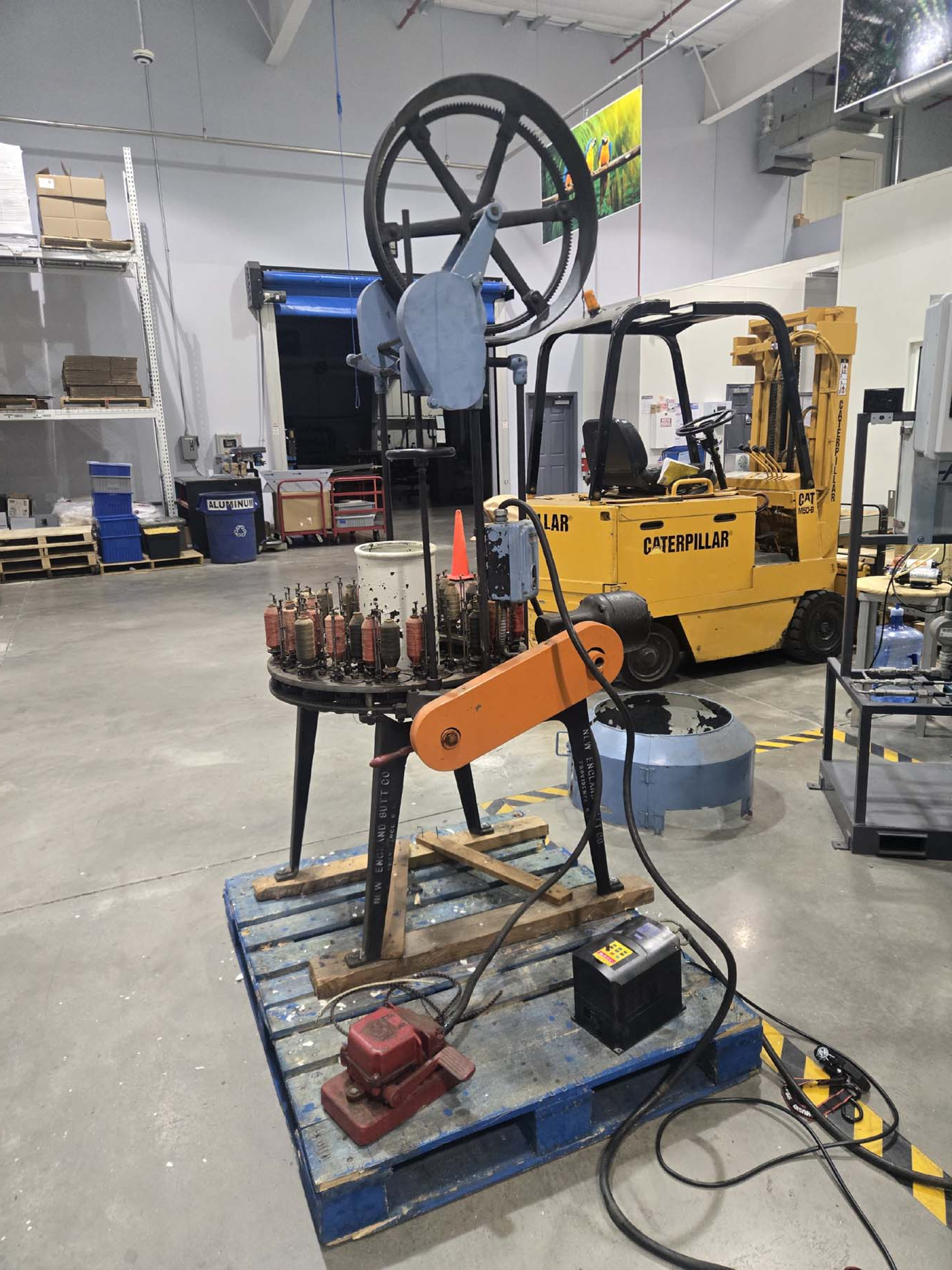

PATENTED FEB 9 9

COME ONE, COME ALL TO THE
FUCKARAMA FILM EXHIBITION
CHALLENGE YOUR NOTIONS ABOUT SEXUALITY AND GENDER
ONE ADMISSION
DAVE ARCHER
FOGGY MOUNTAIN
SKUNK ESSENCE
THE BRIDE!




ASHRAE 52 test d t set up for
ASHRAE .2
(Method for testing Ult olet Lam
NEW ENGLAND BUTT CO.
PROV. R.I.
NEW ENGLAND BUTT CO.
PROV. R.I.

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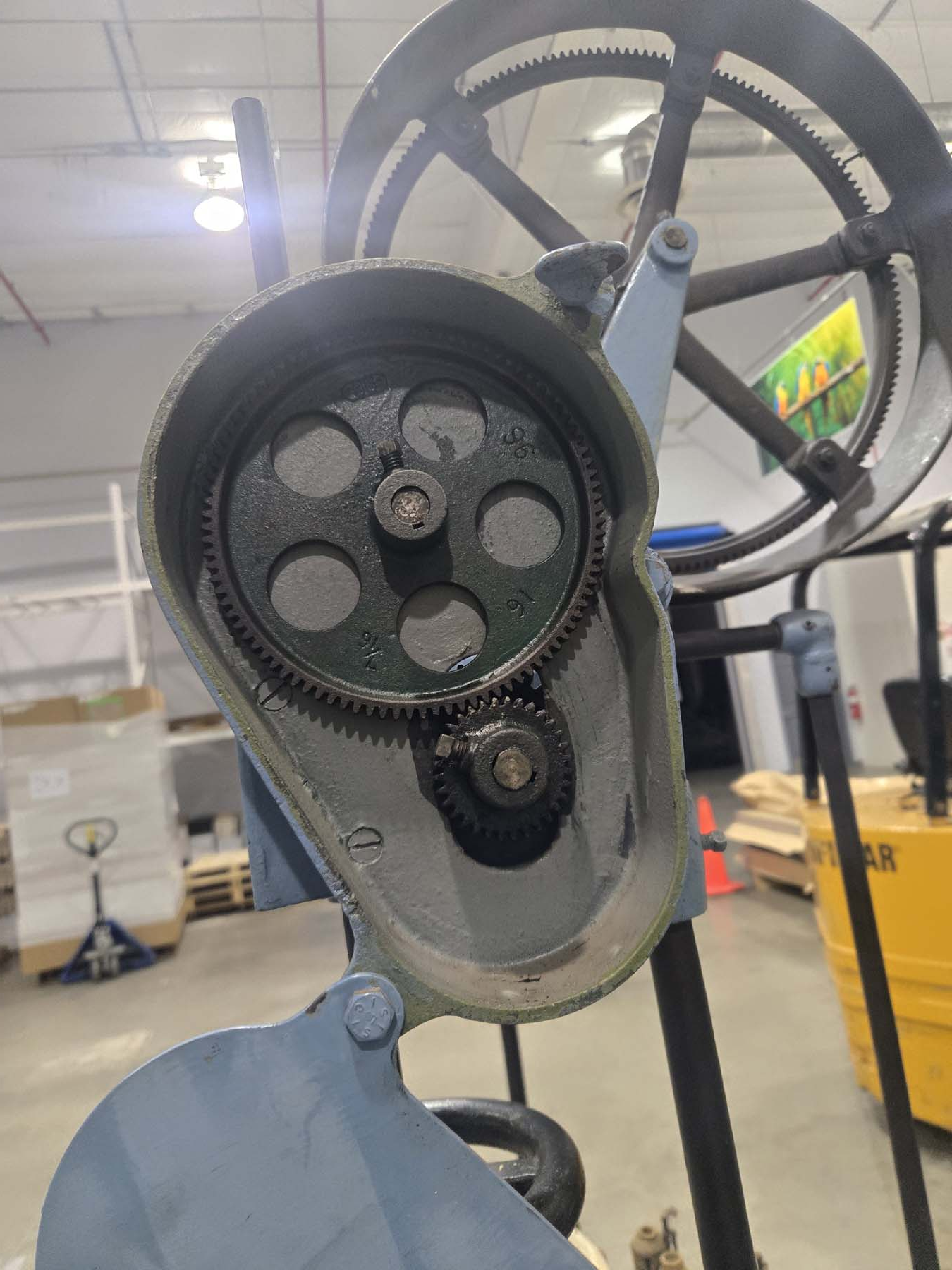
PROVIDENCE R.I.
CATERPILLAR
CAT
M50-B
ALUMINUM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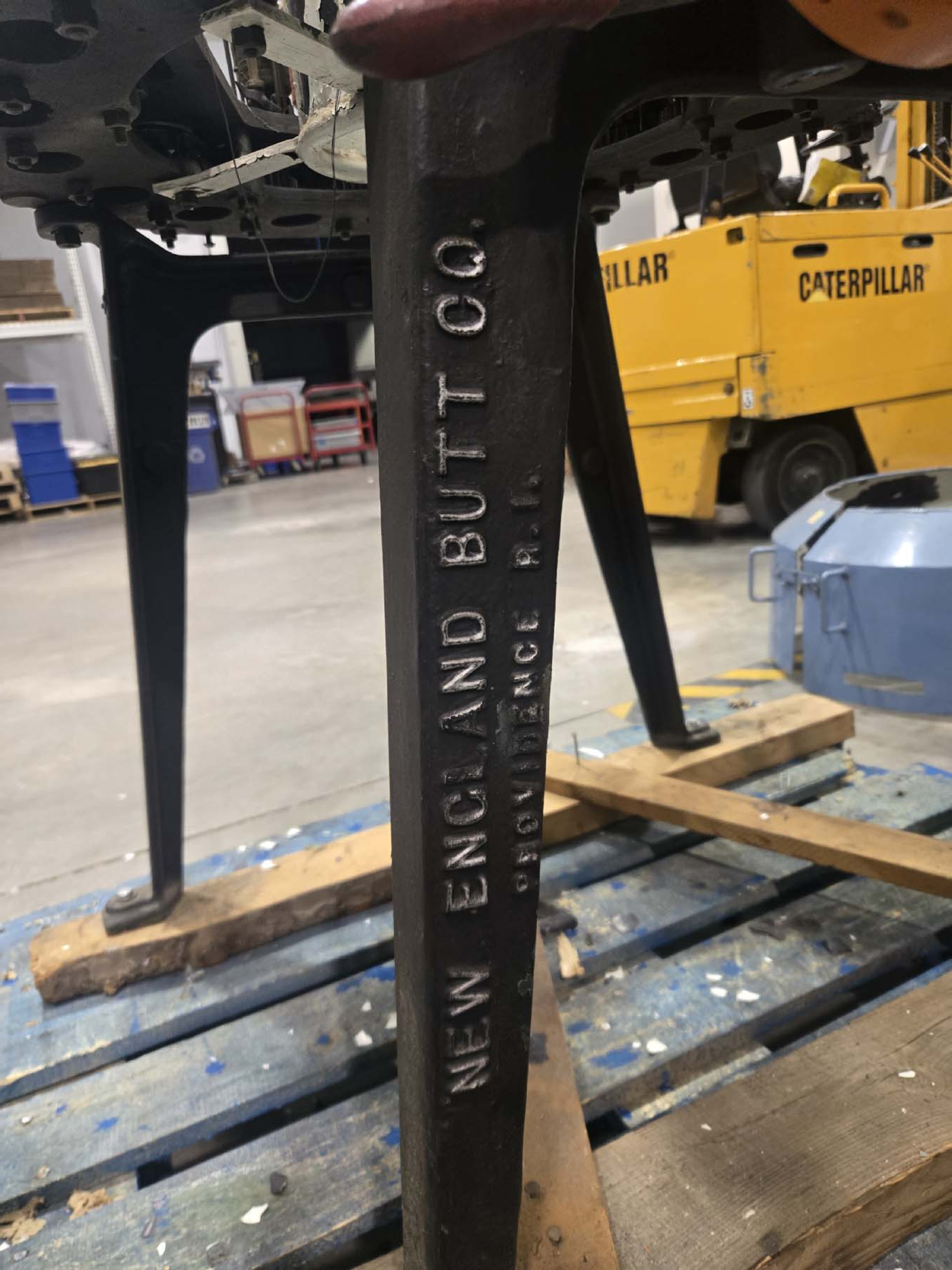
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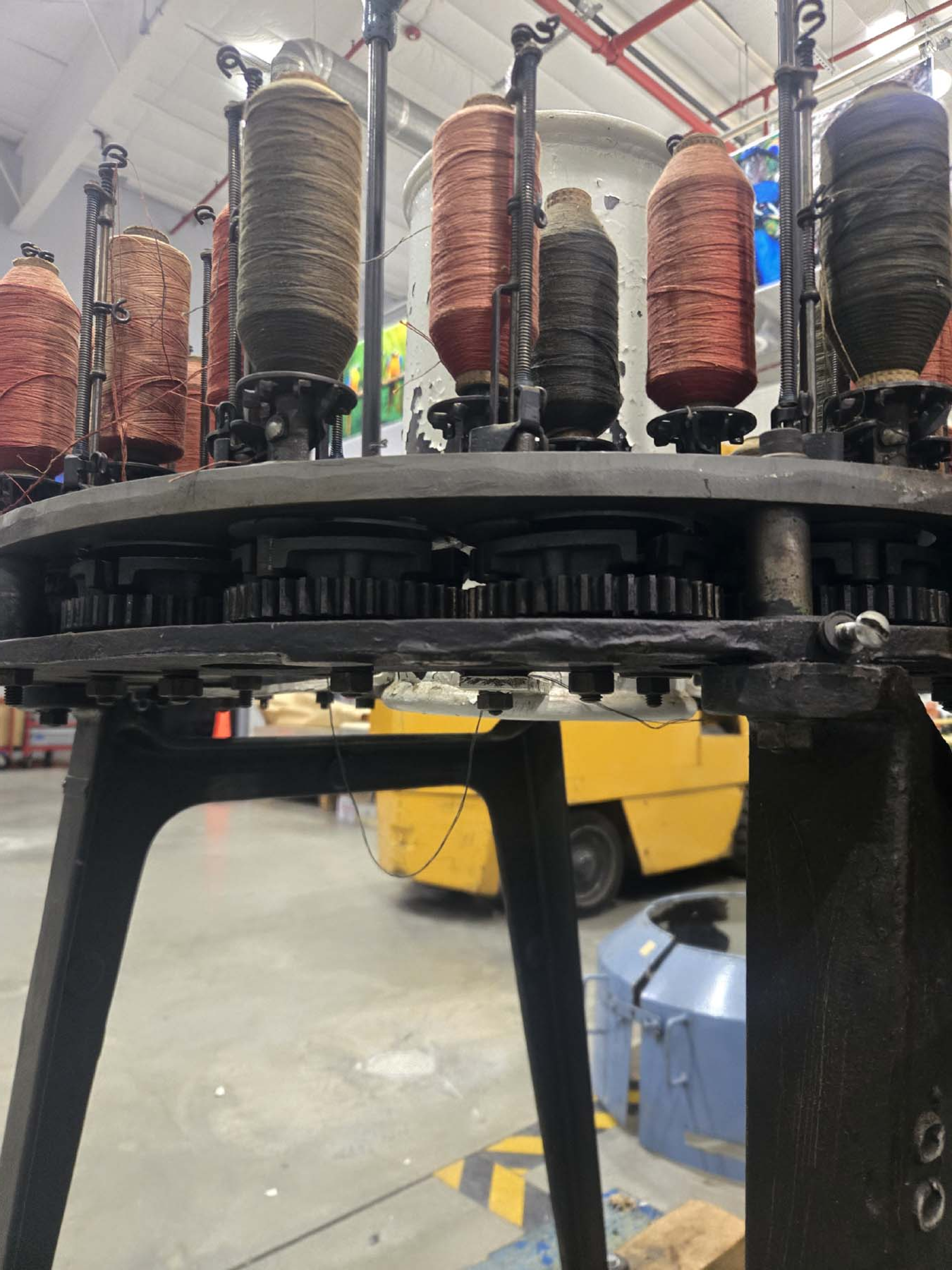
PROVIDENCE R.I.
ILLAR
CATERPILLAR



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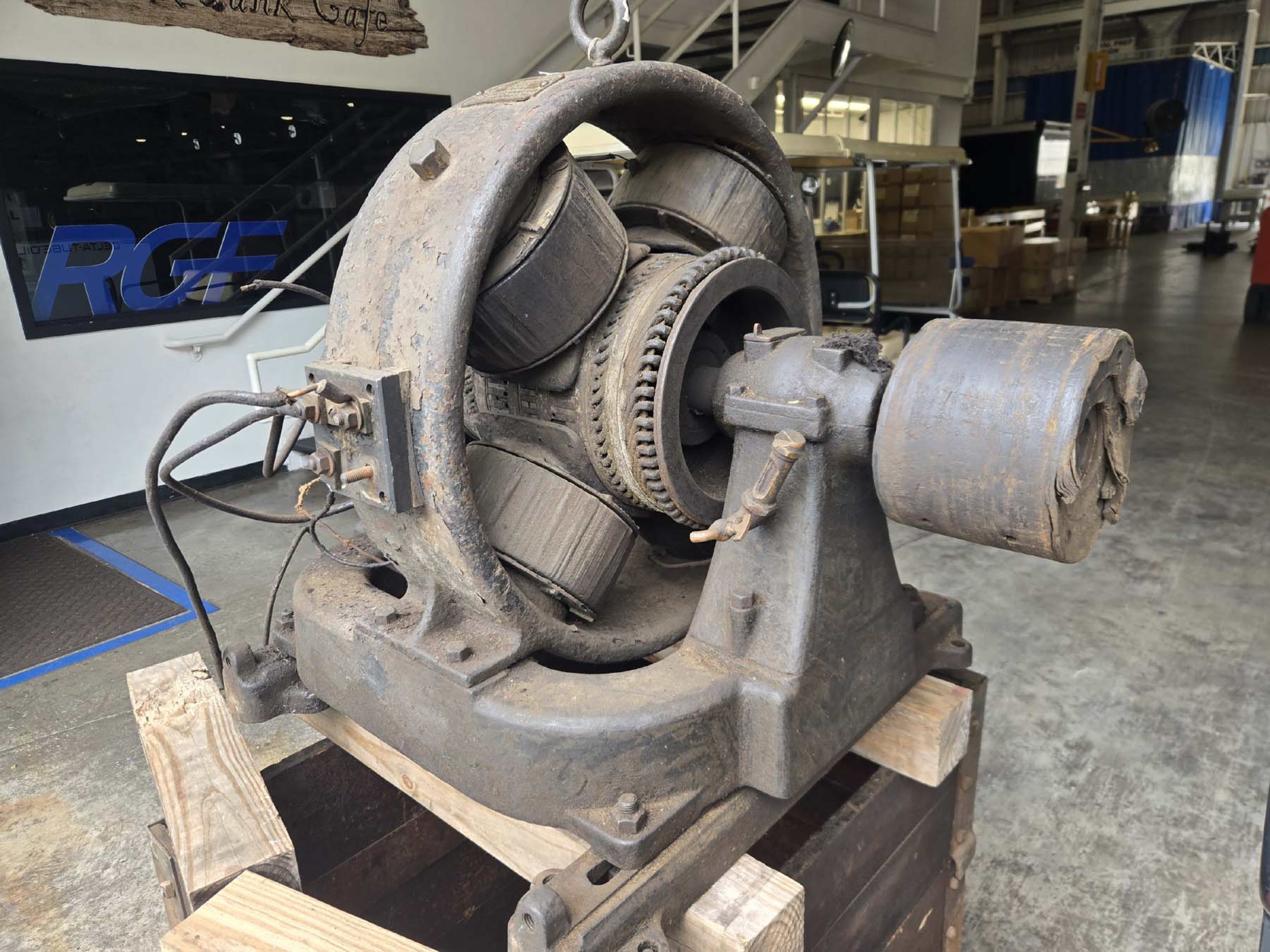
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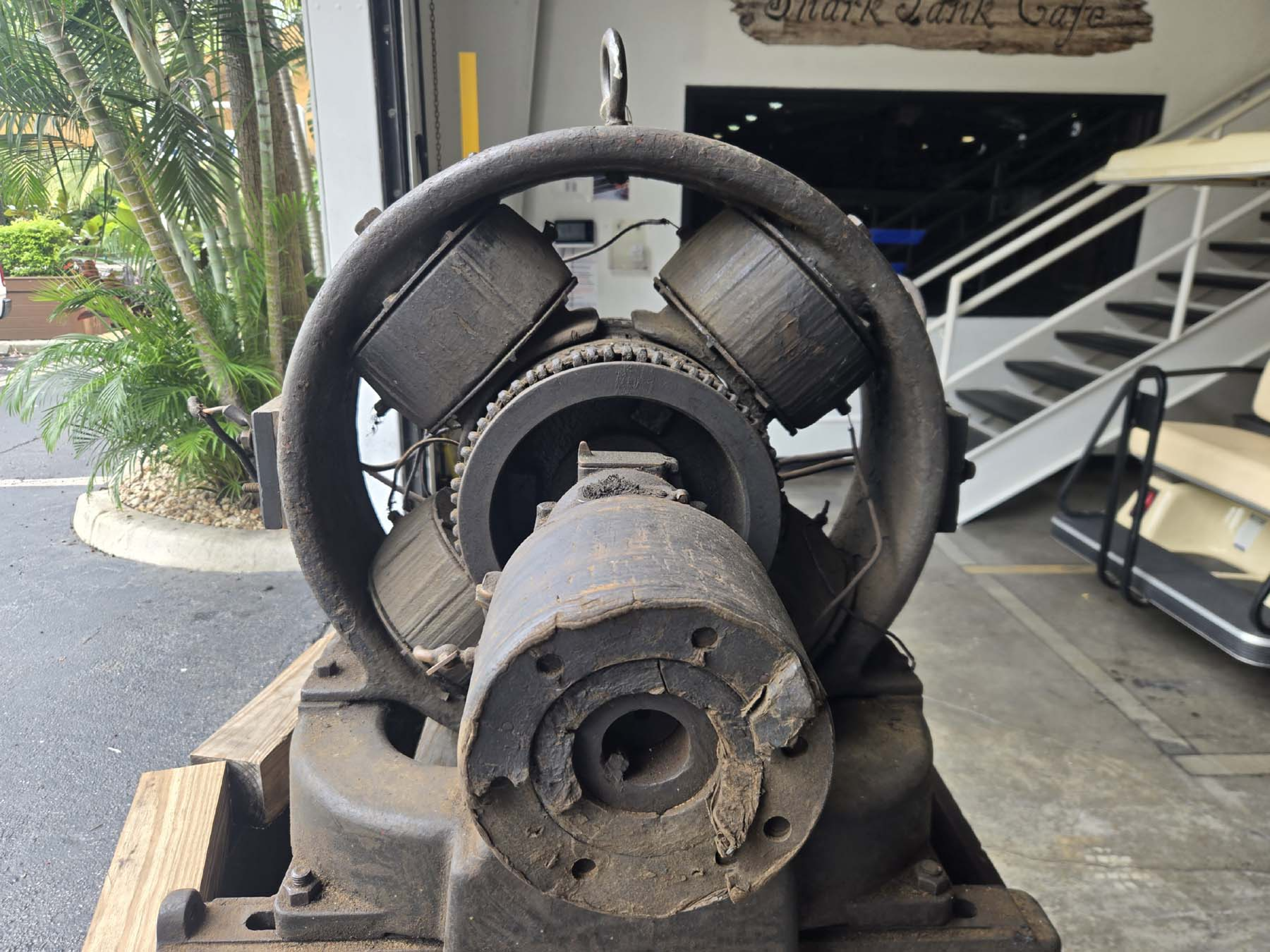
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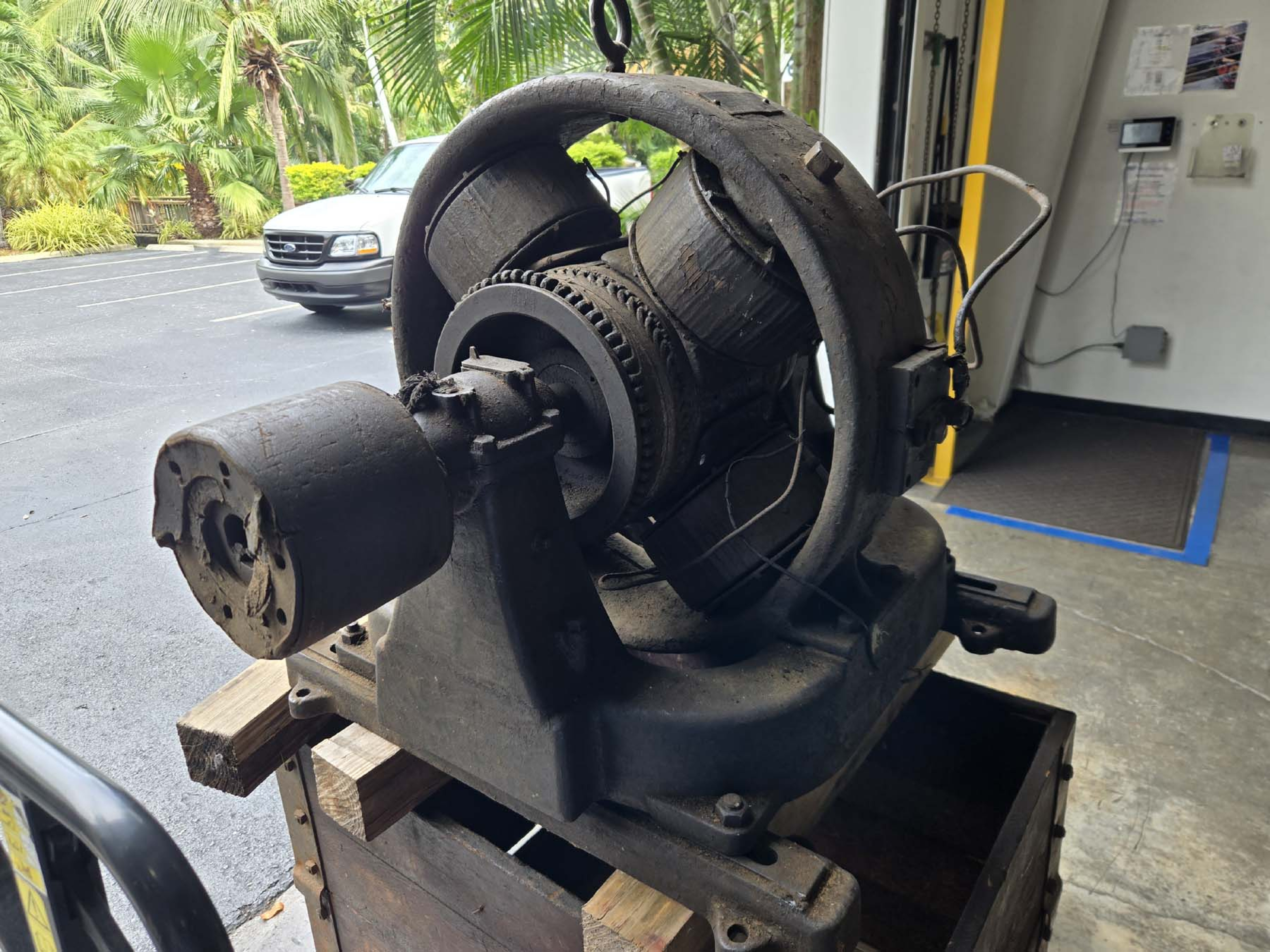
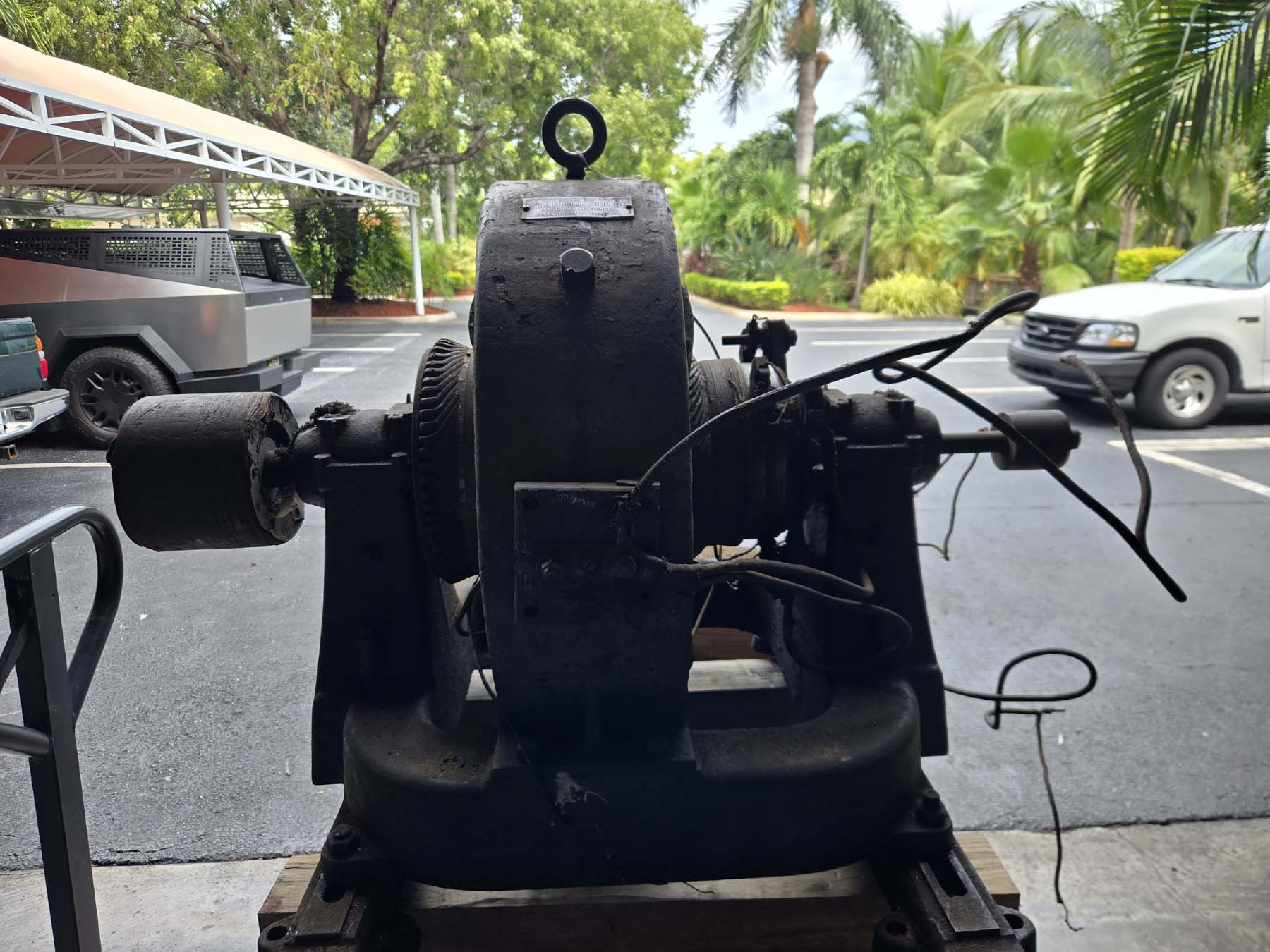
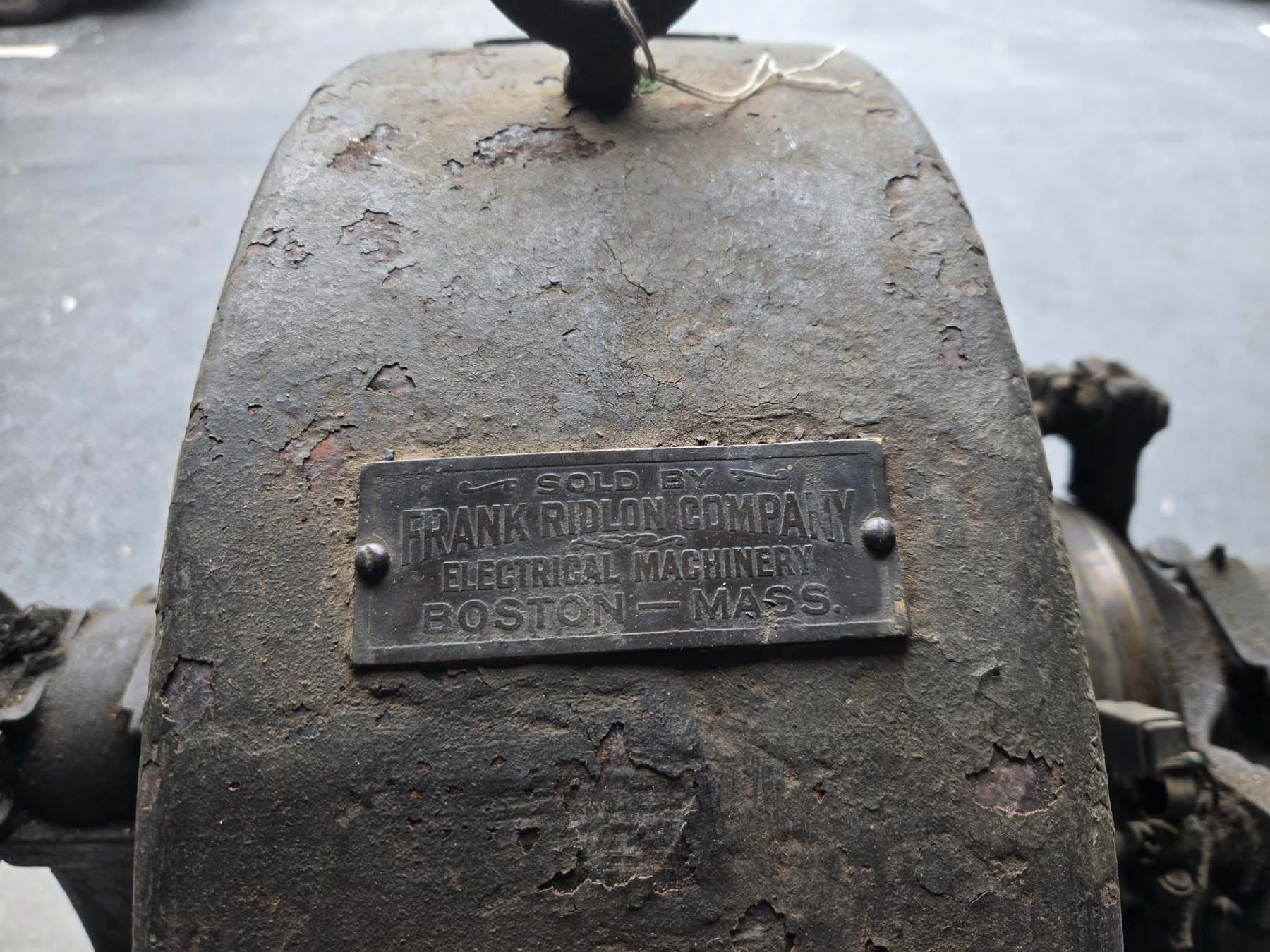
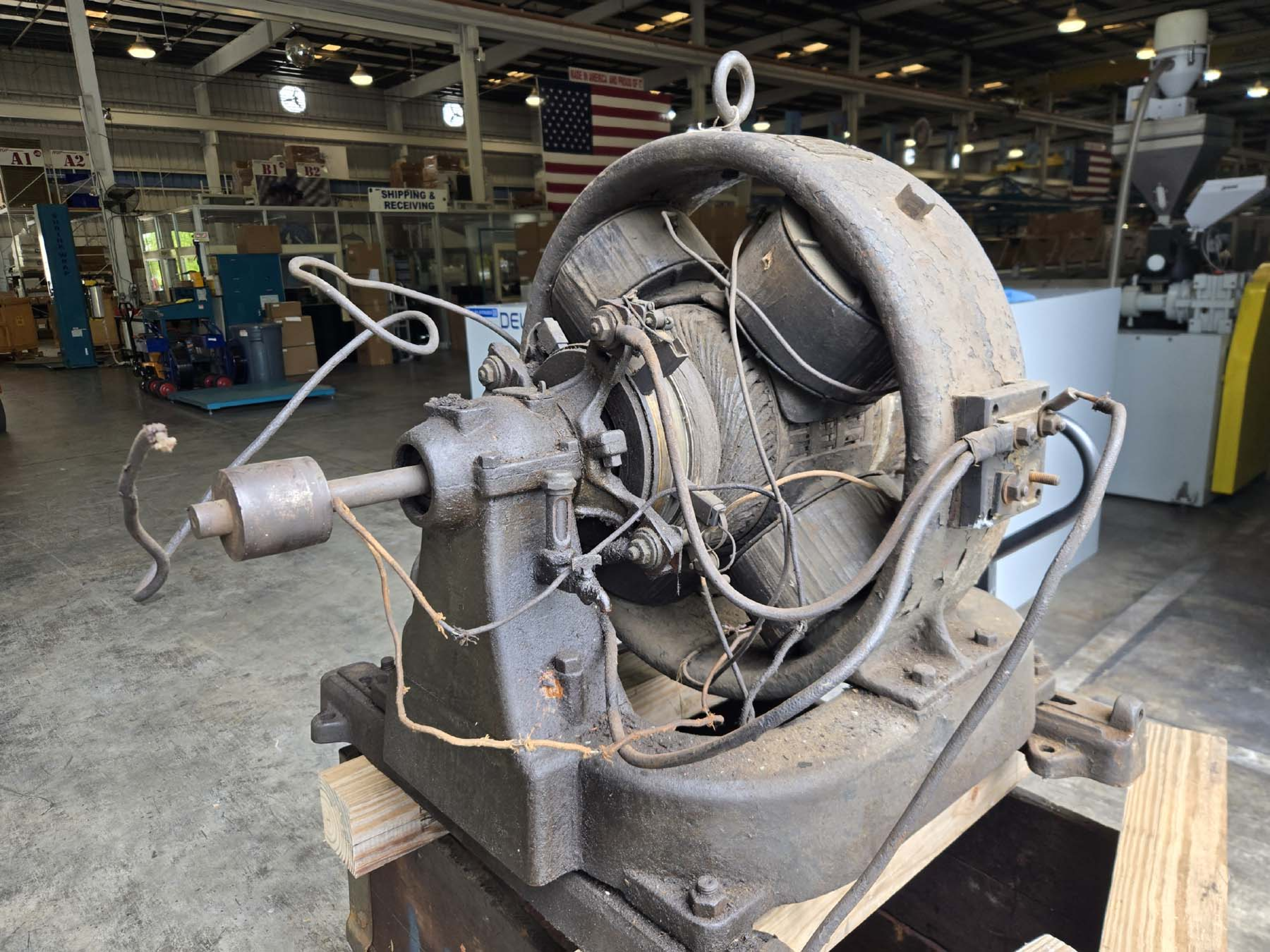
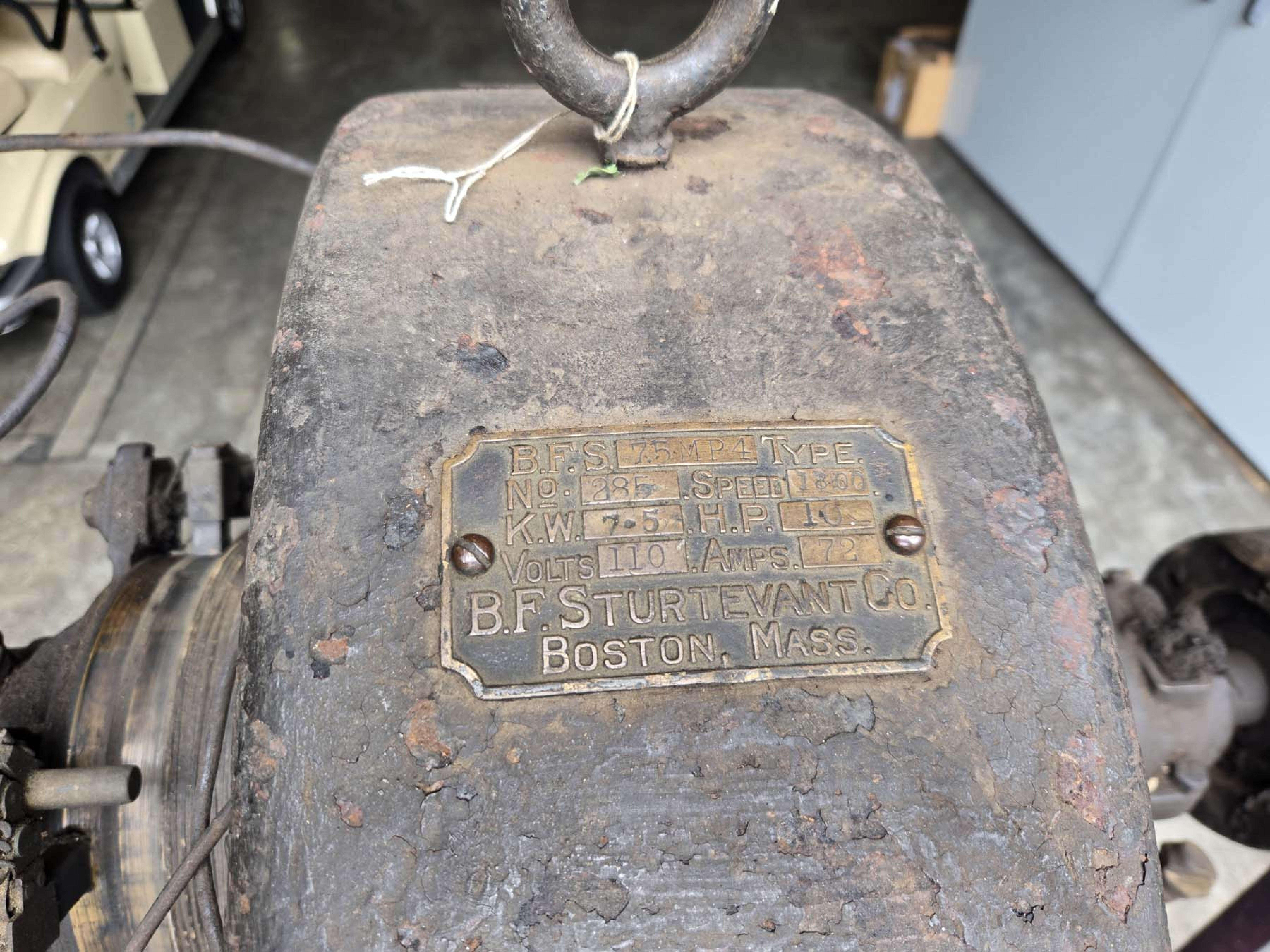





SOLD BY
FRANK RIDLON COMPANY
ELECTRICAL MACHINERY
BOSTON — MASS.


A1
A2
B1
B2
SHIPPING &
RECEIVING
MADE IN AMERICA AND PROUD OF IT



B.F.S. 75 MP4 TYPE.
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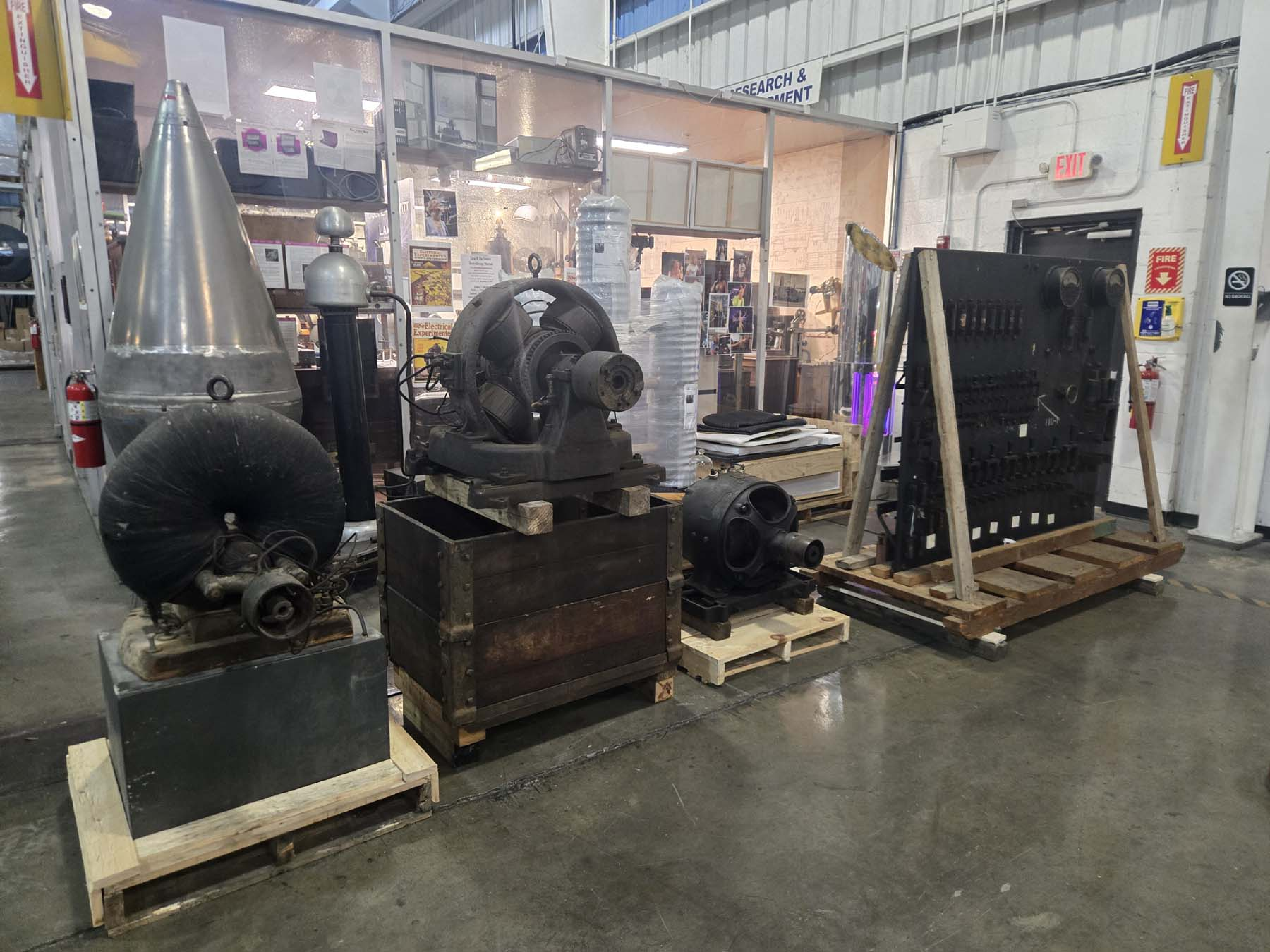
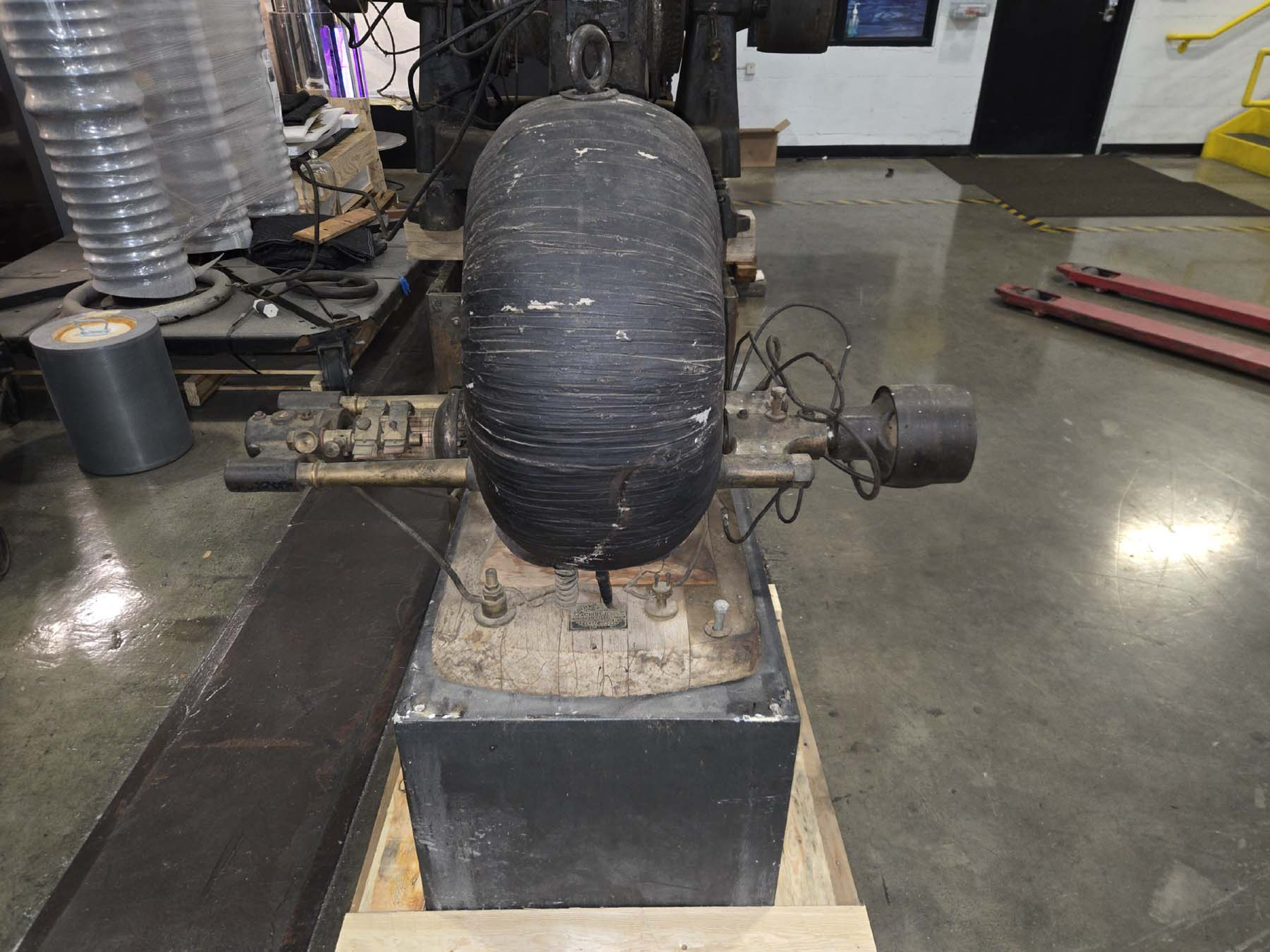
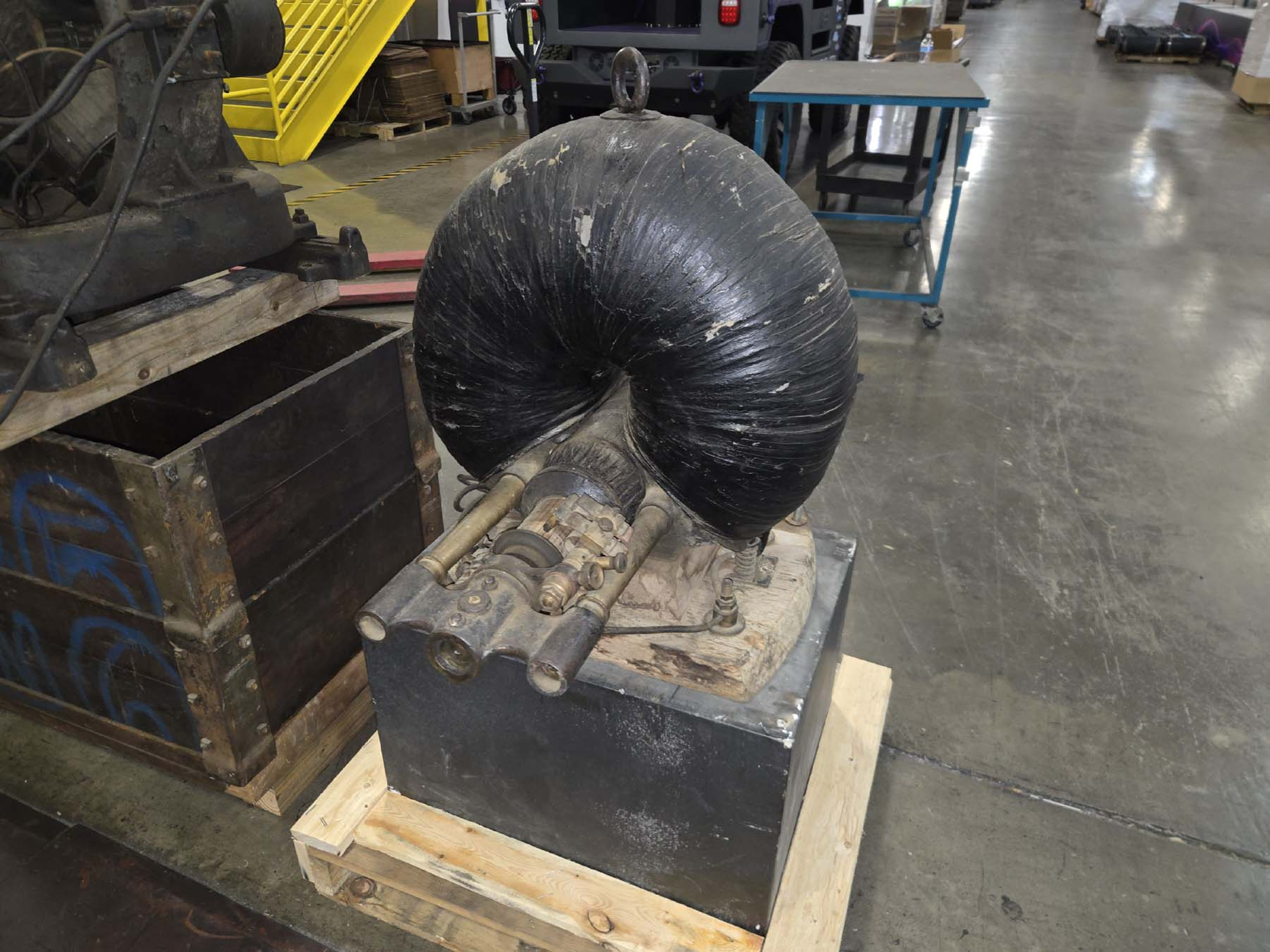
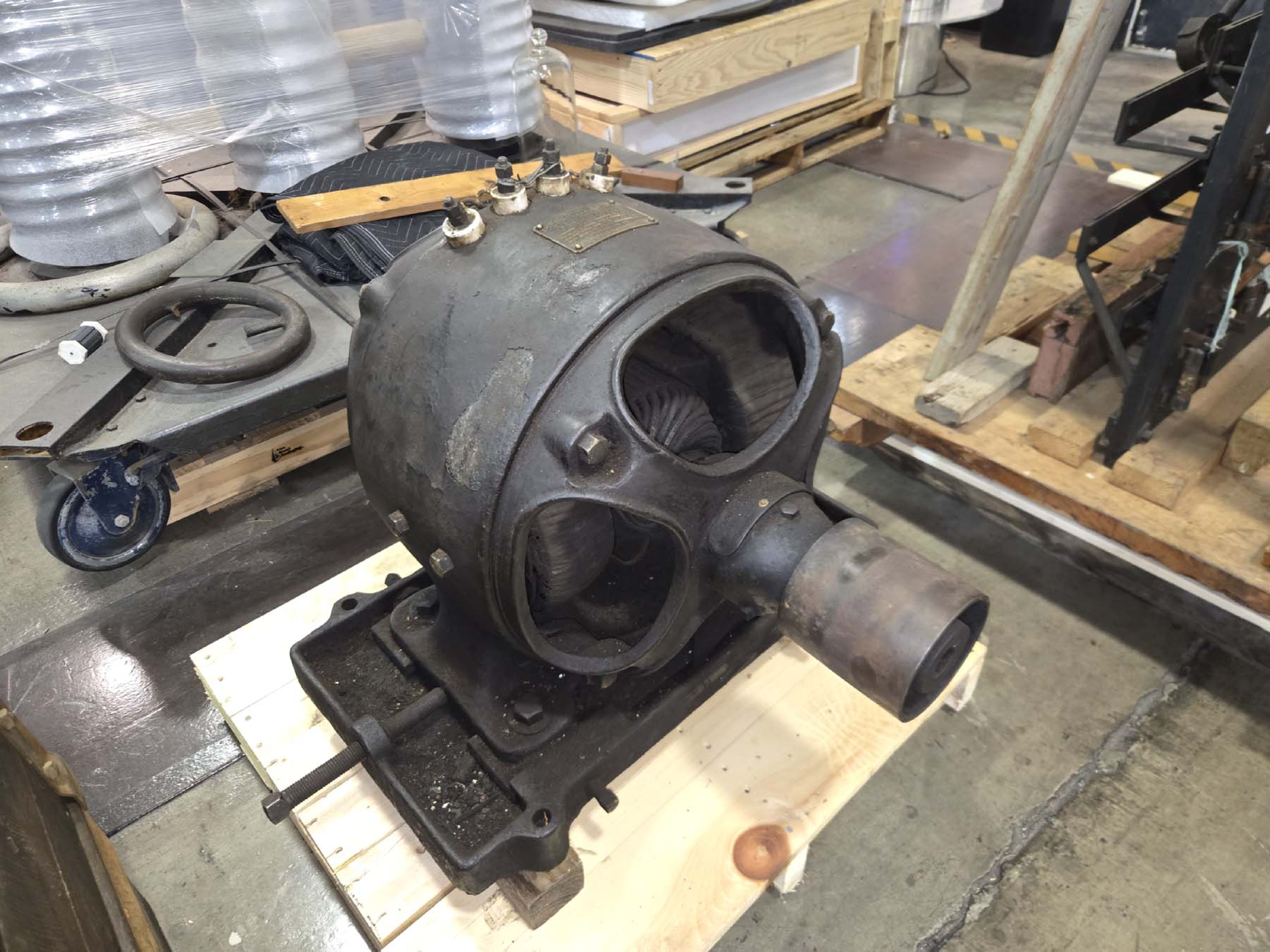
BOSTON, MASS.

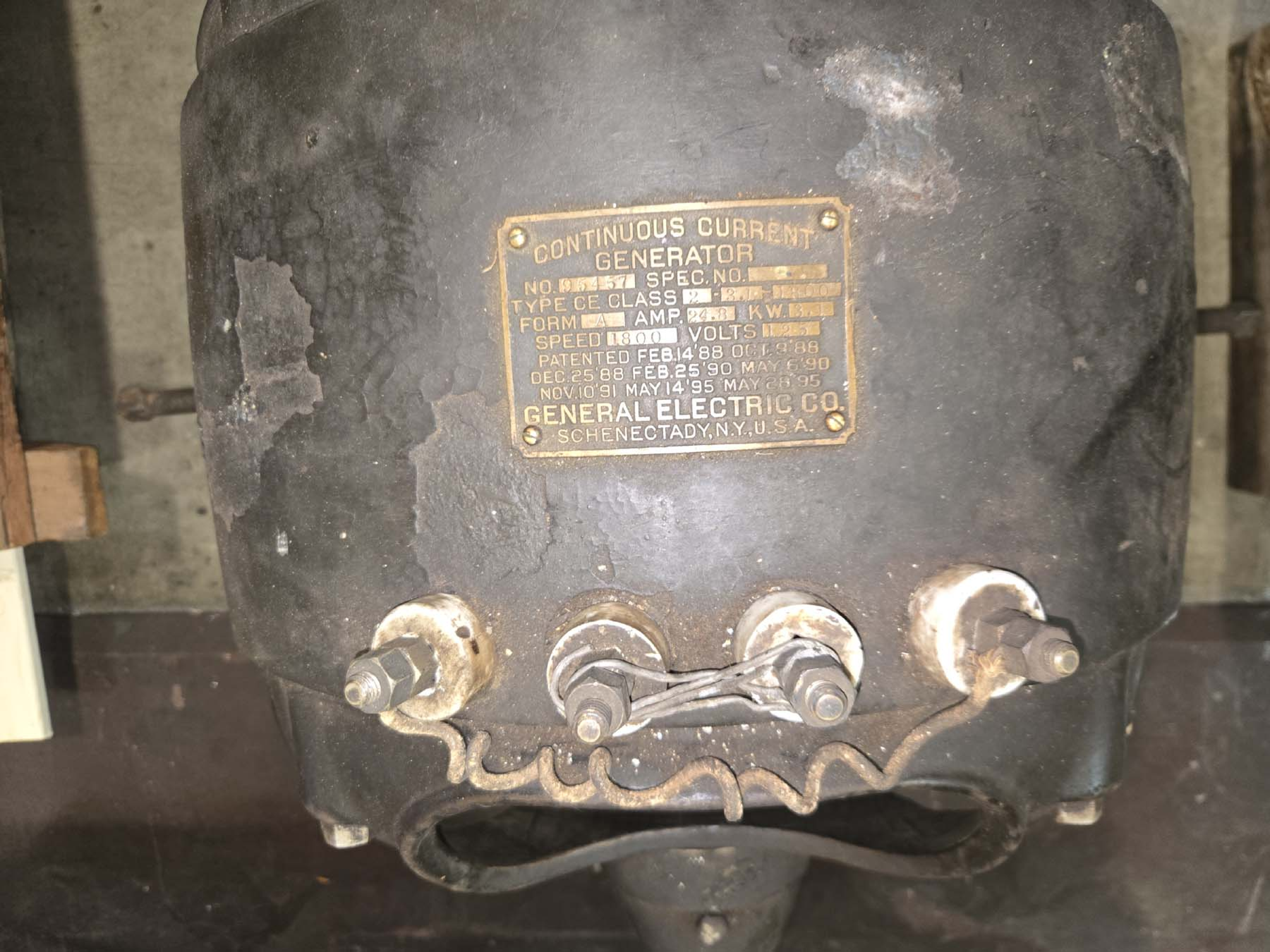

FIRE EXTINGUISHER
RESEARCH &
EXIT
FIRE
FIRE EXTINGUISHER

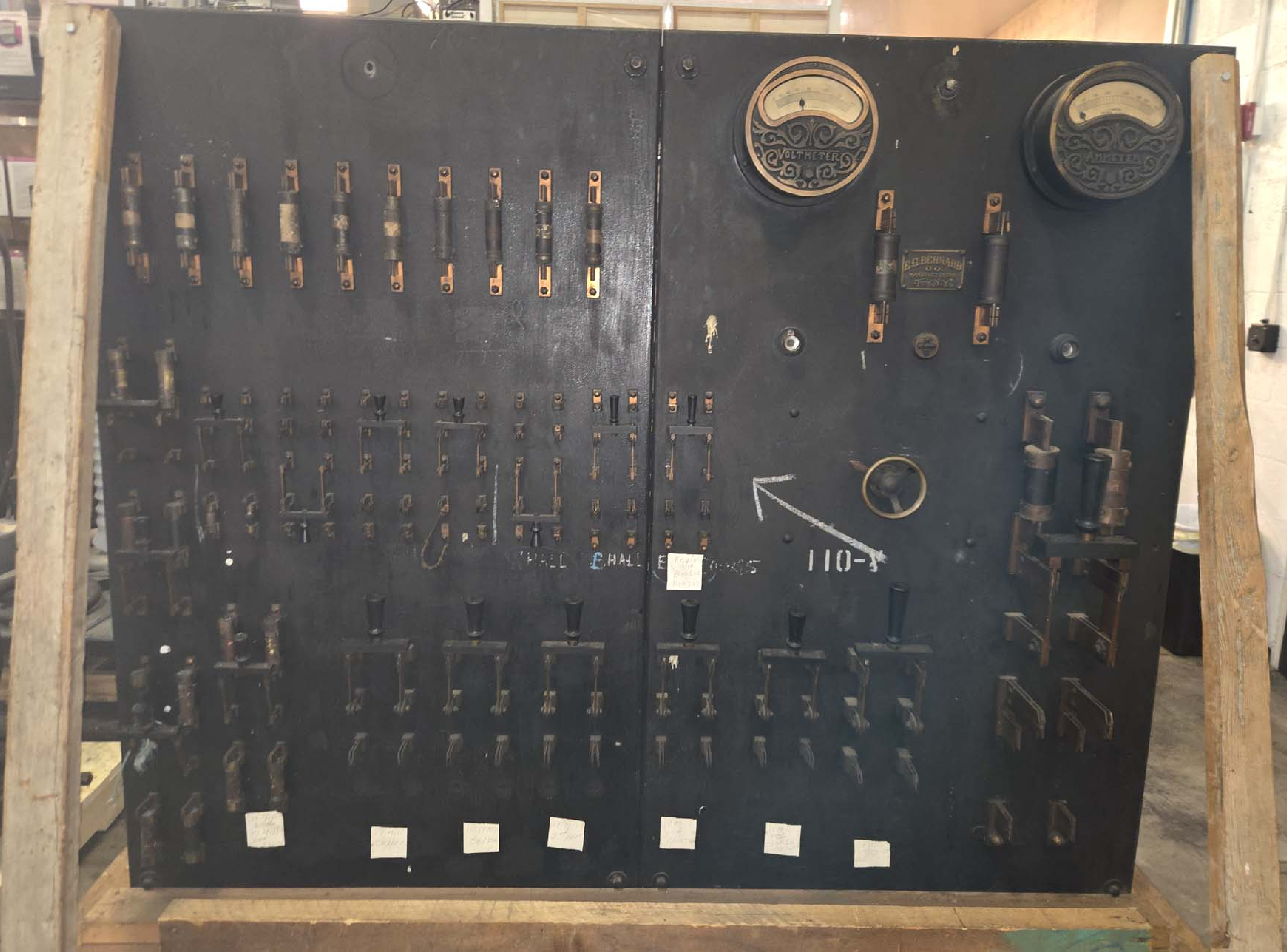
ELECTRICAL EXPERIMENTER
Turn Of The Century Electrotherapy Museum
The Electrical Experimenter

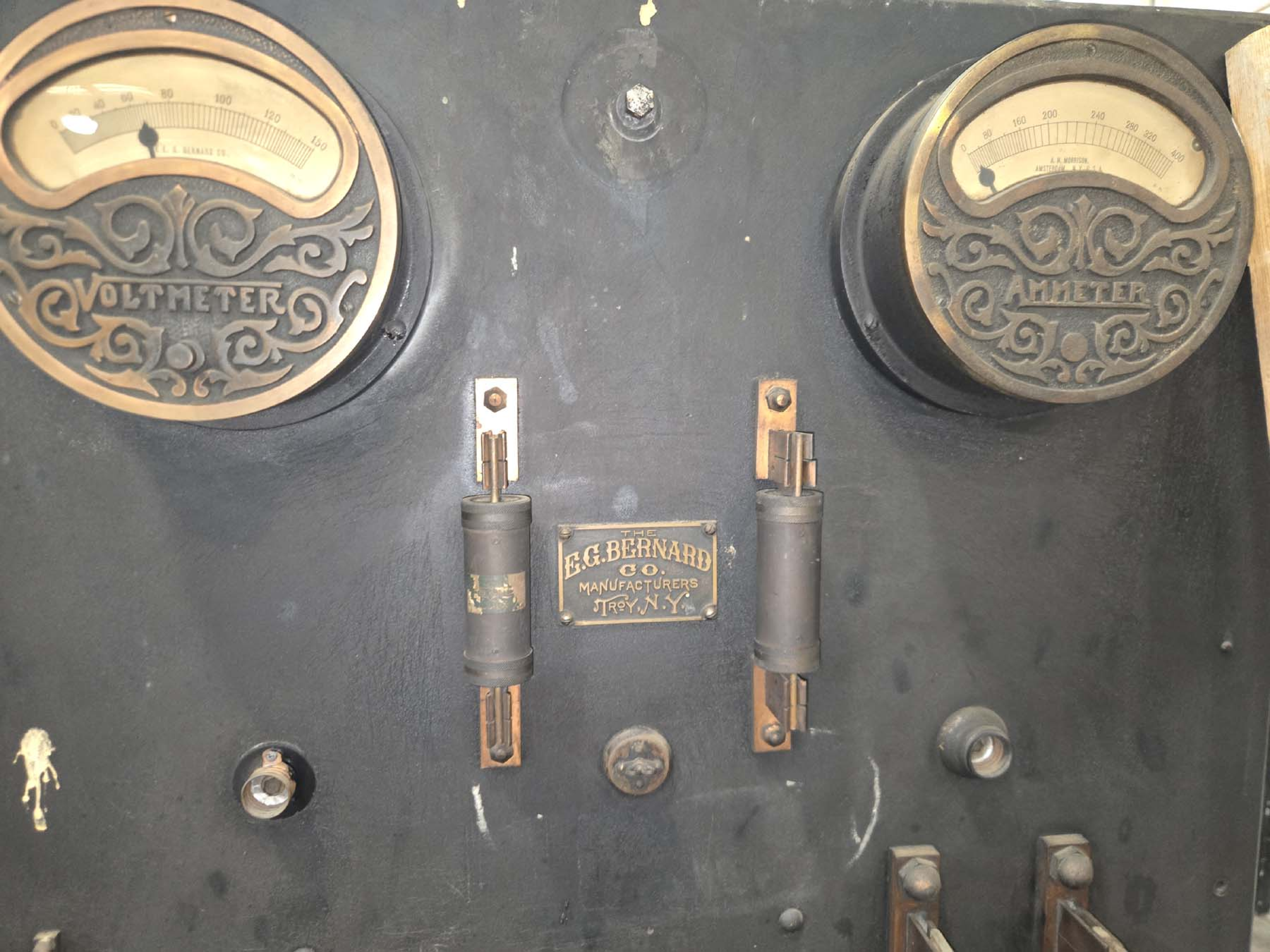




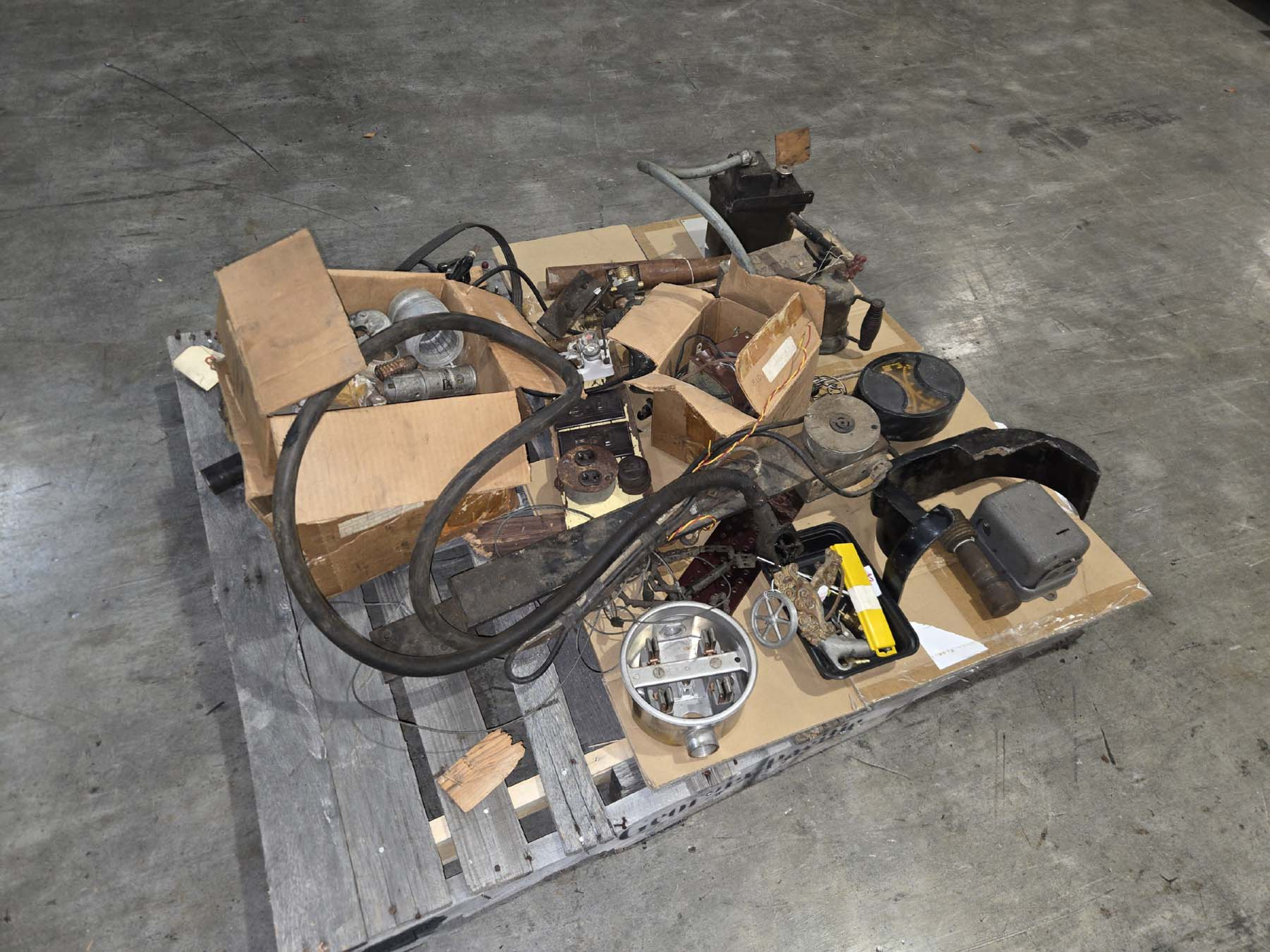


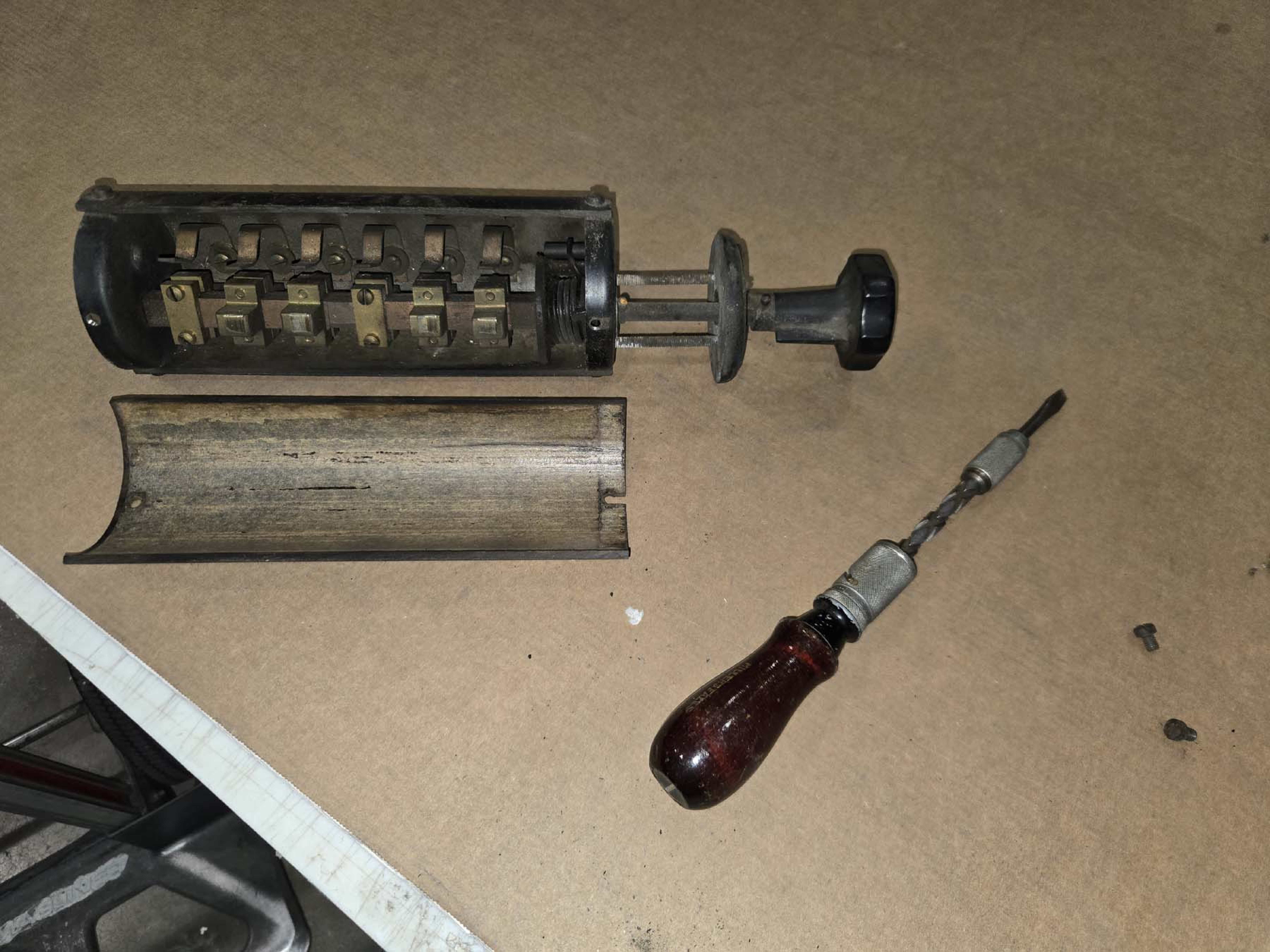

CONTINUOUS CURRENT GENERATOR
NO. 95457 SPEC. NO.
TYPE CE CLASS 2-3.1-1800
FORM A AMP. 24.8 KW. 3.1
SPEED 1800 VOLTS 125
PATENTED FEB.14'88 OCT.9'88
DEC.25'88 FEB.25'90 MAY 6'90
NOV.10'91 MAY 14'95 MAY 28'95
GENERAL ELECTRIC CO.
SCHENECTADY, N.Y., U.S.A.

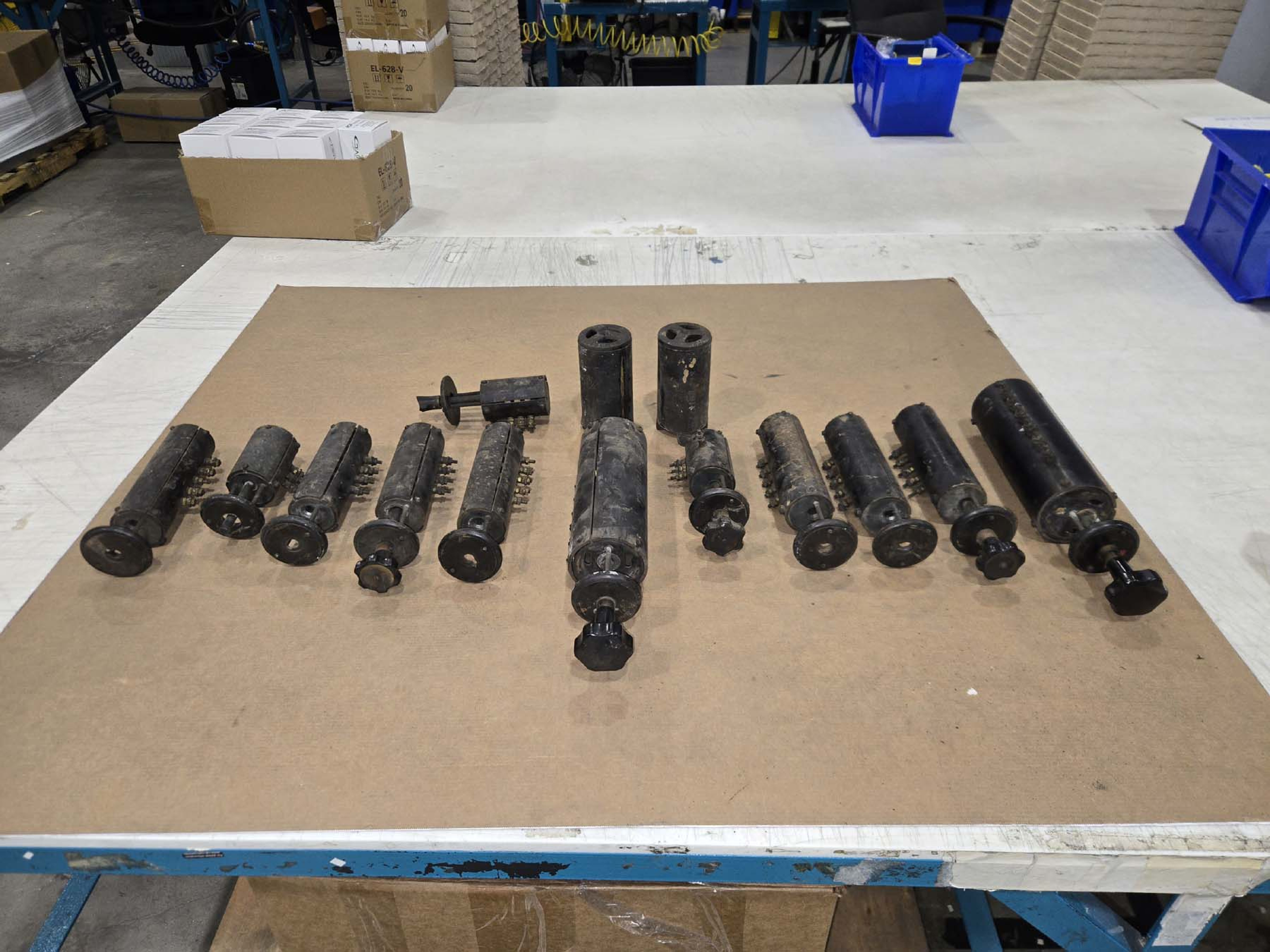

9
VOLTMETER
AMMETER
E.G. BERNARD
CO.
TROY, N.Y.
HALL
HALL
110-V


0
20
40
60
80
100
120
150
E. G. BERNARD CO.
VOLTMETER
0
80
160
200
240
280
320
400
A. H. MORRISON,
AMSTERDAM, N.Y. U.S.A.
AMMETER
THE
E.G. BERNARD
CO.
MANUFACTURERS
TROY, N.Y.

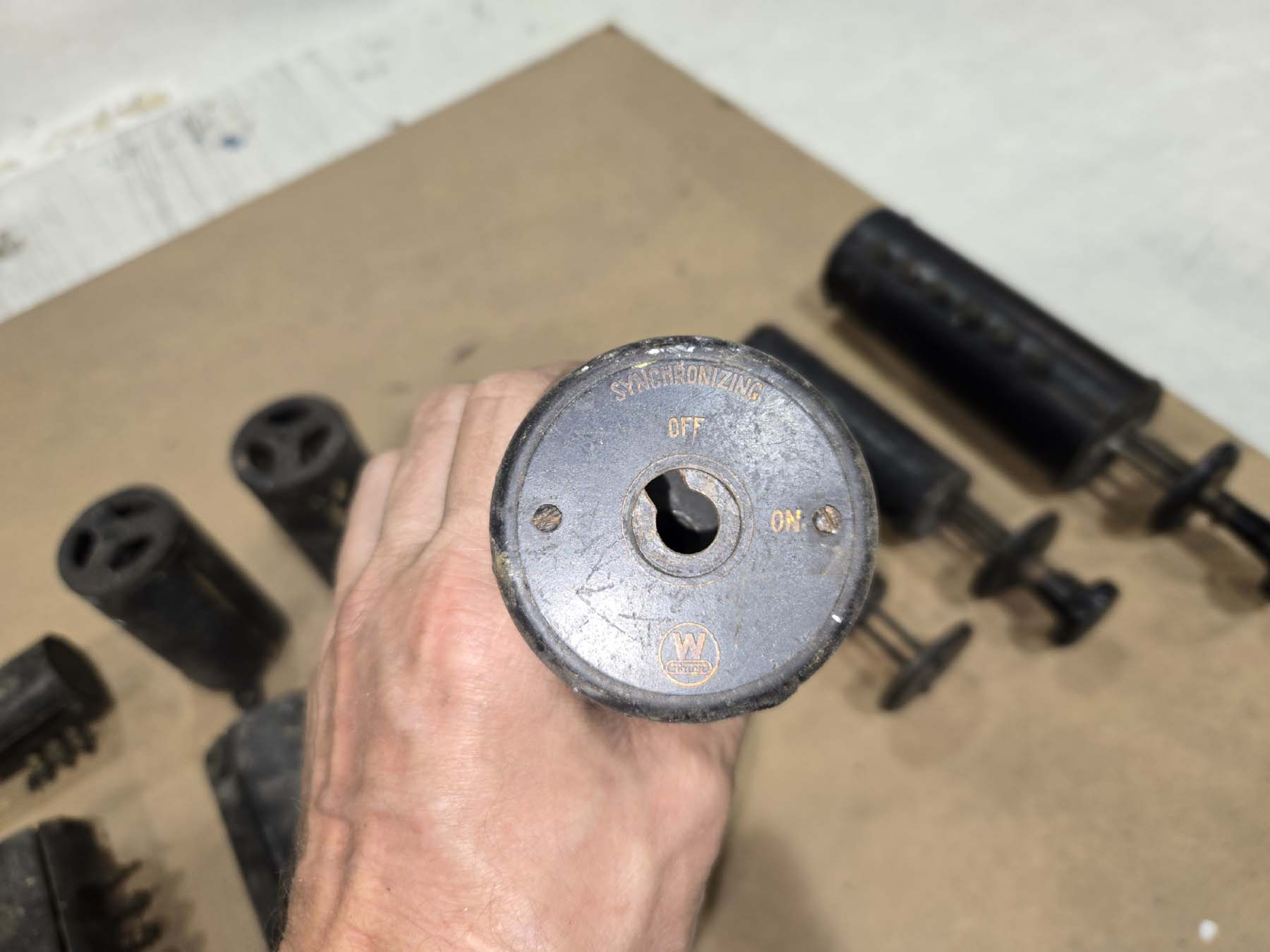
W HALL
E HALL
E [redacted] ROOMS
110-3

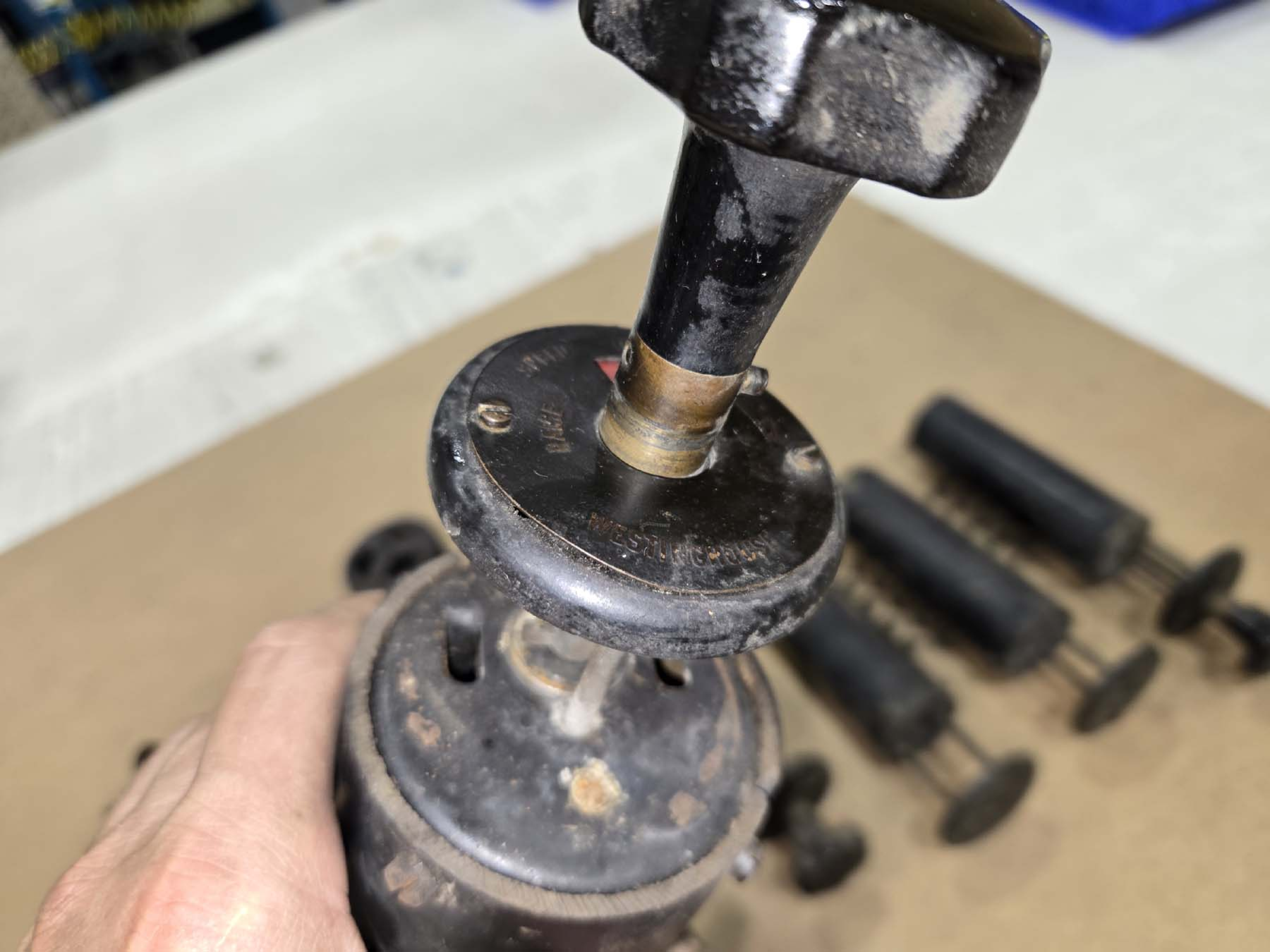


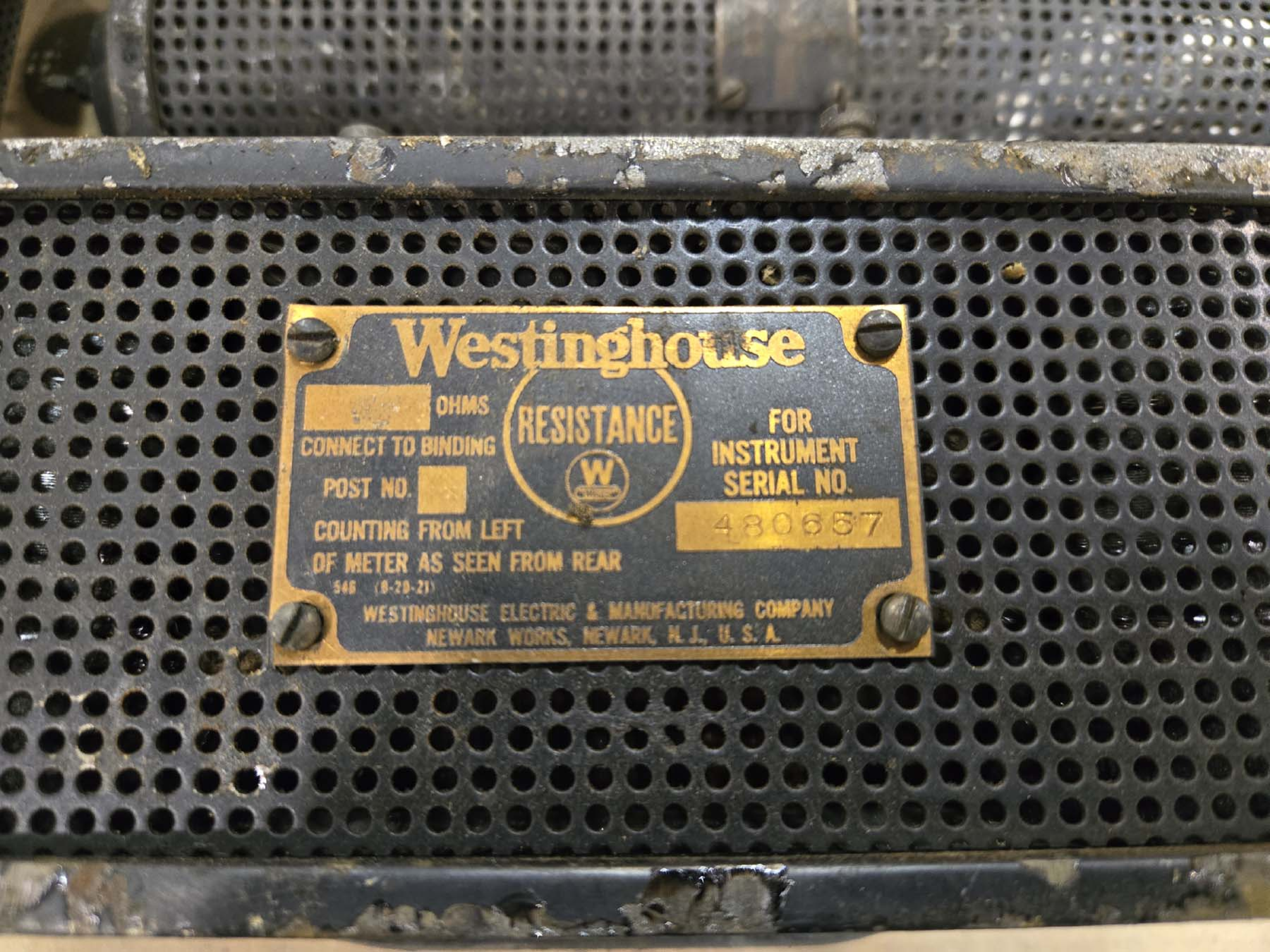




EL-628-V
20


SYNCHRONIZING
OFF
ON
W


WESTINGHOUS



Westinghouse

[illegible] OHMS

CONNECT TO BINDING

POST NO.

COUNTING FROM LEFT

OF METER AS SEEN FROM REAR

RESISTANCE

FOR

INSTRUMENT

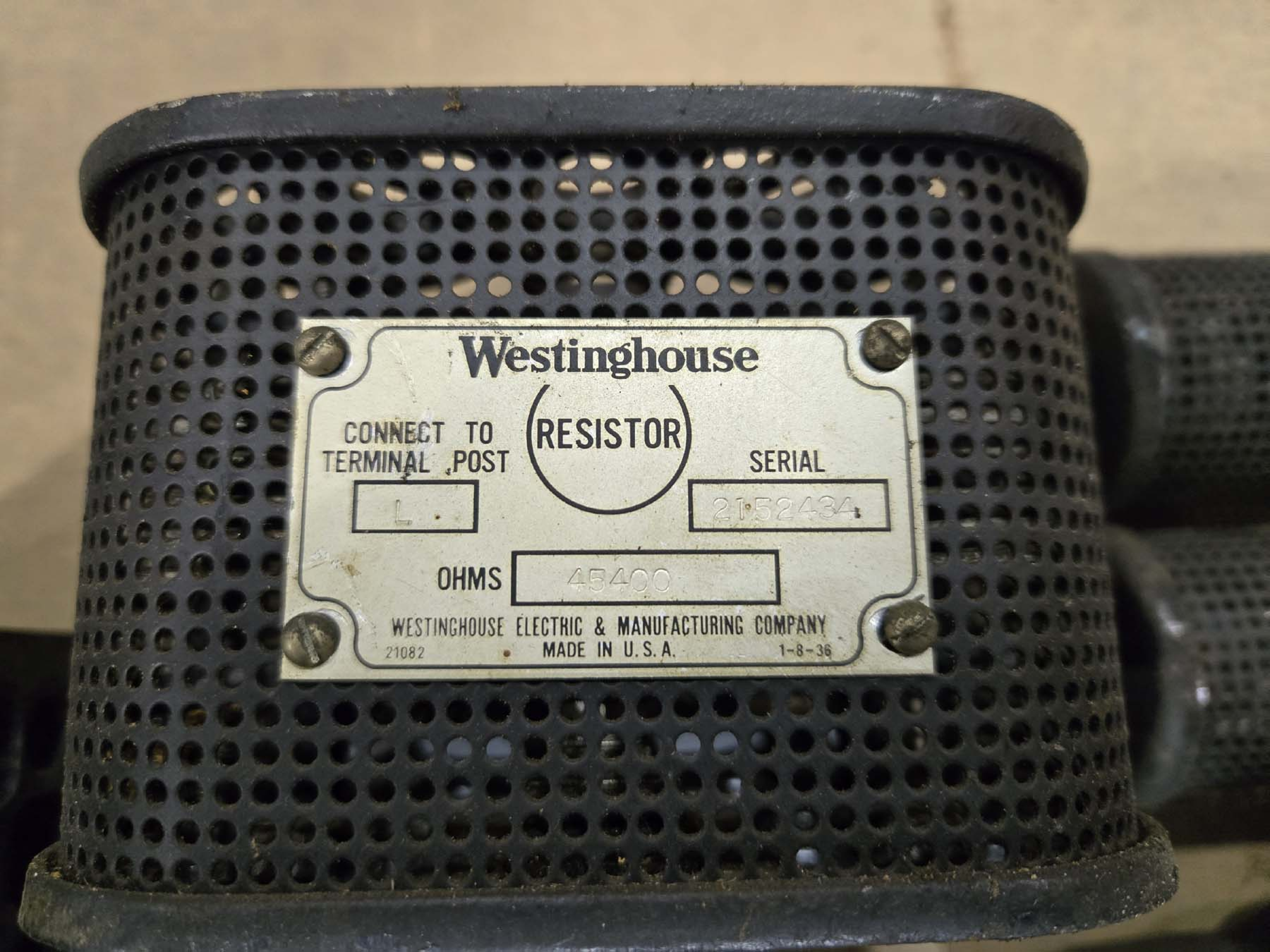
SERIAL NO.

480657

546 (8-20-21)

WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY

NEWARK WORKS, NEWARK, N. J., U. S. A.



Westinghouse

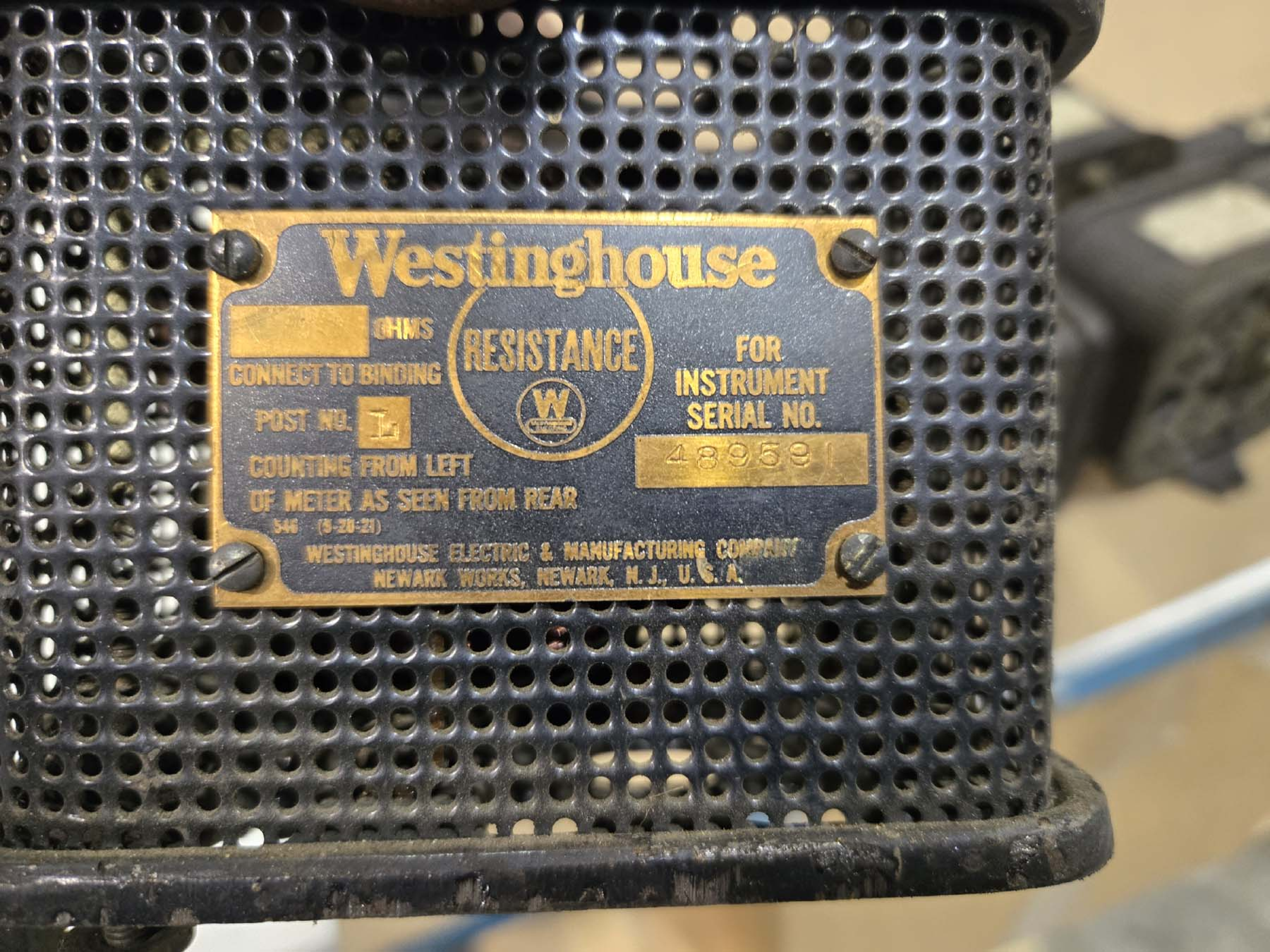
RESISTOR

CONNECT TO TERMINAL POST
L

SERIAL
2152434

OHMS
45400

WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY
21082 MADE IN U.S.A. 1-8-36



Westinghouse

OHMS

CONNECT TO BINDING

POST NO. 1

COUNTING FROM LEFT

OF METER AS SEEN FROM REAR

546 (3-20-21)

RESISTANCE

FOR

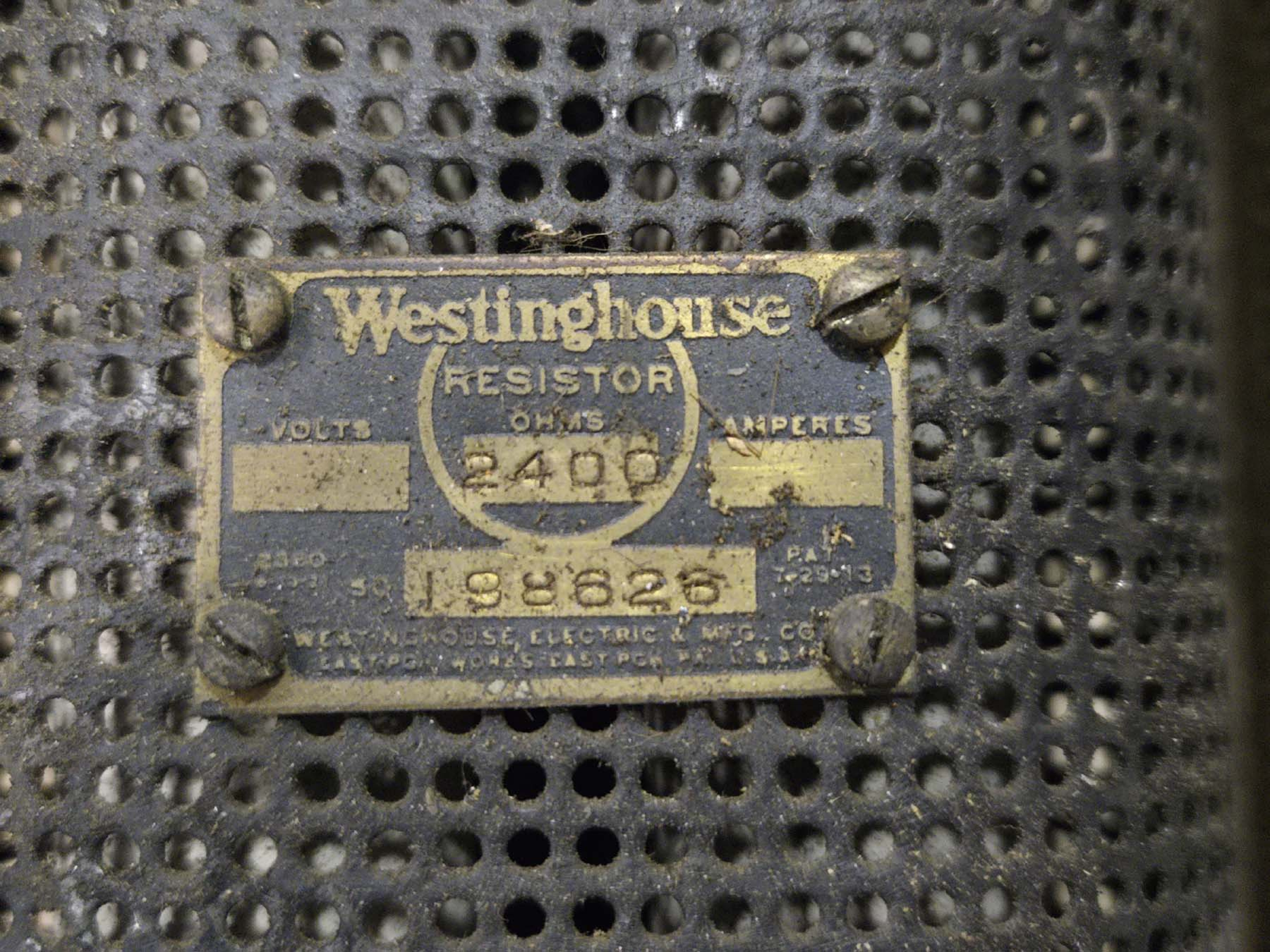
INSTRUMENT

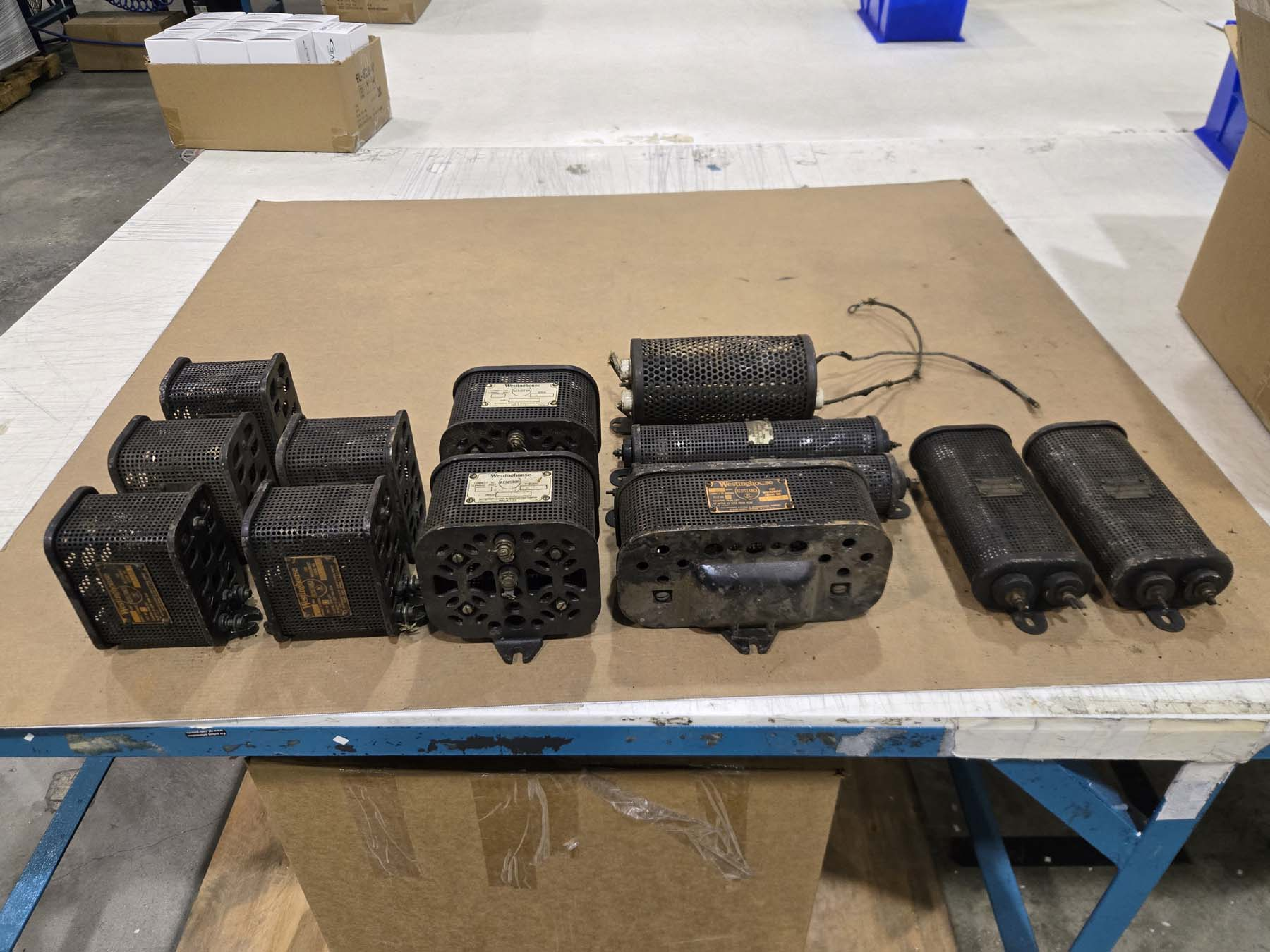
SERIAL NO.

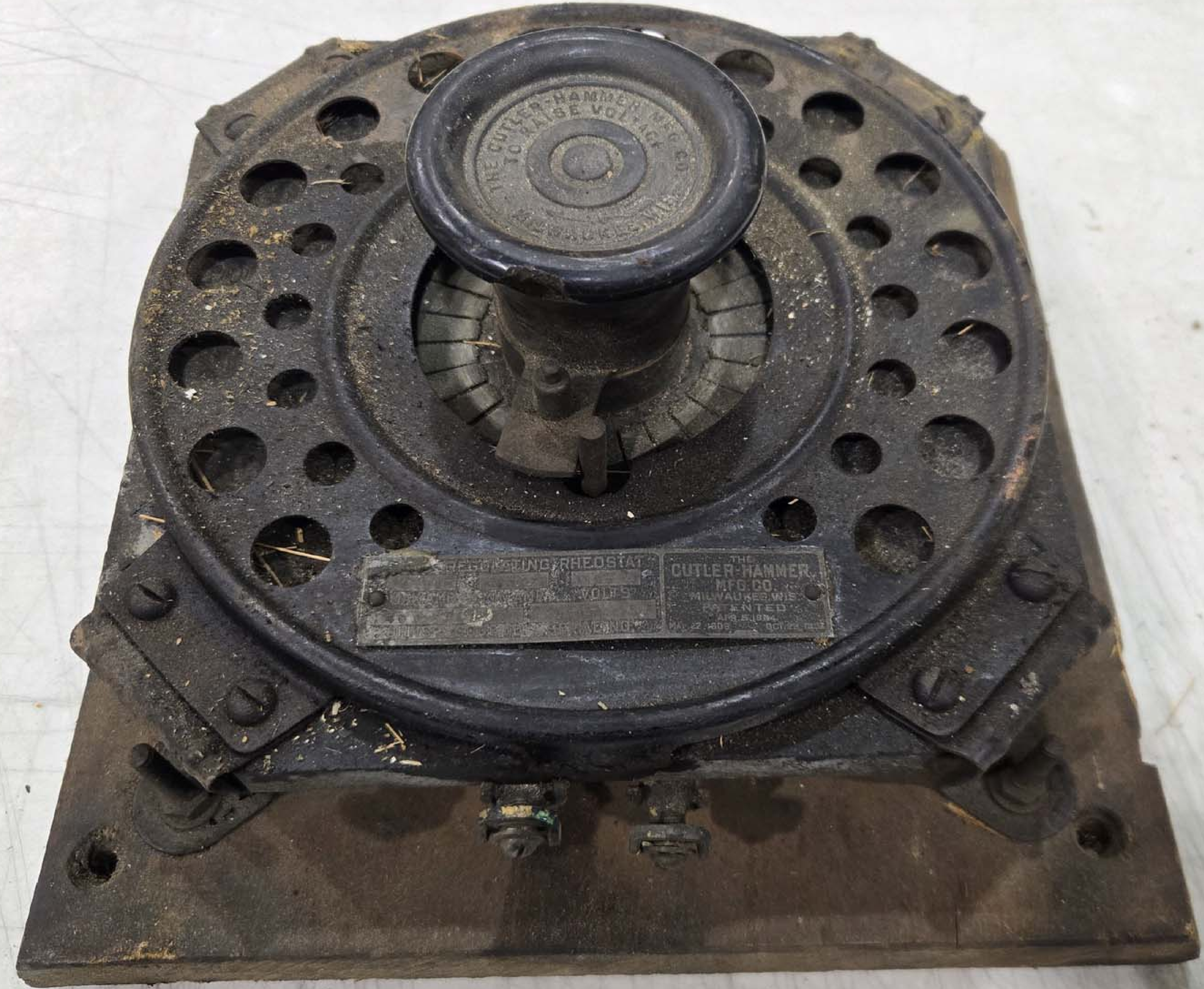
489591

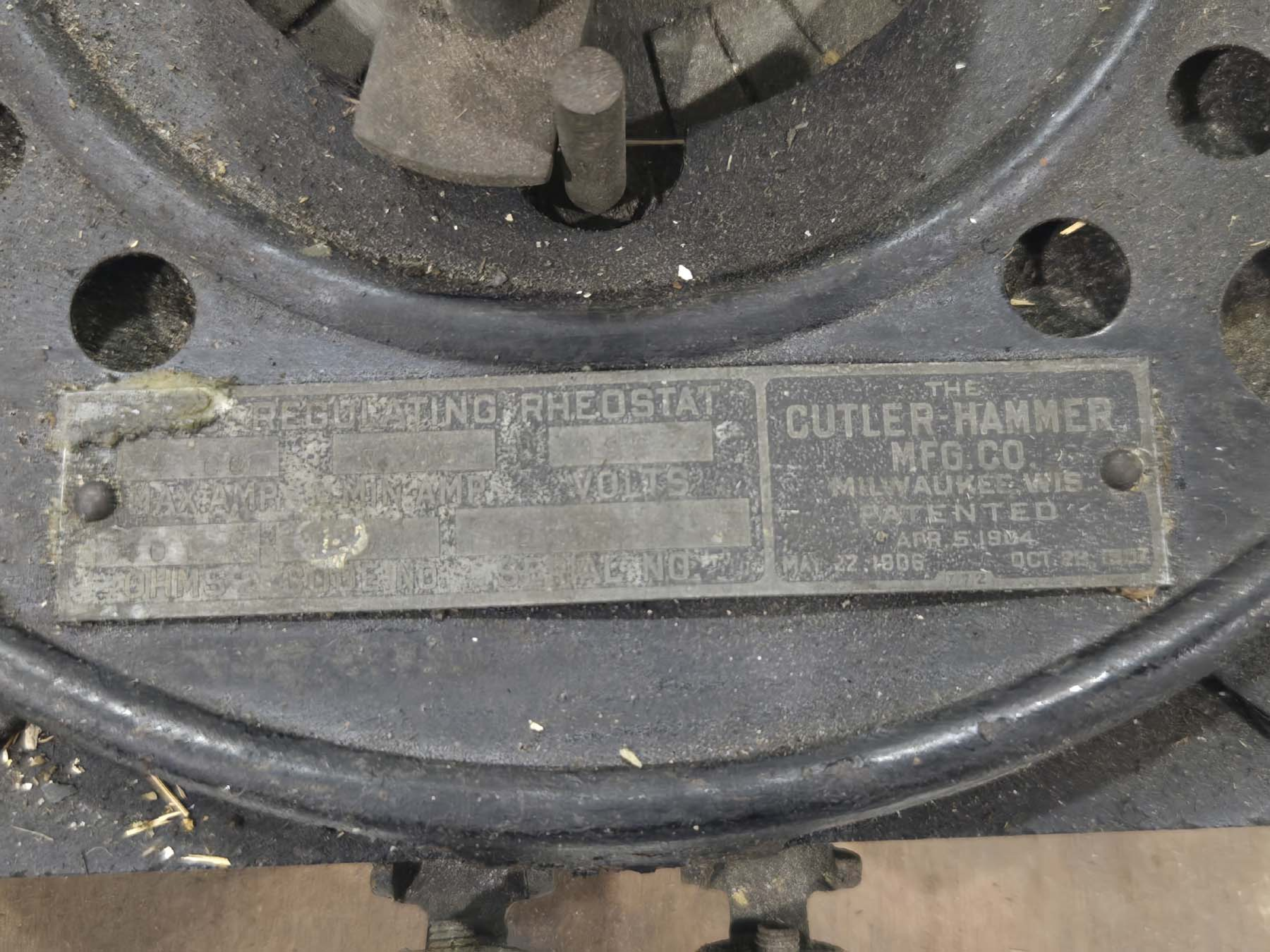
WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY

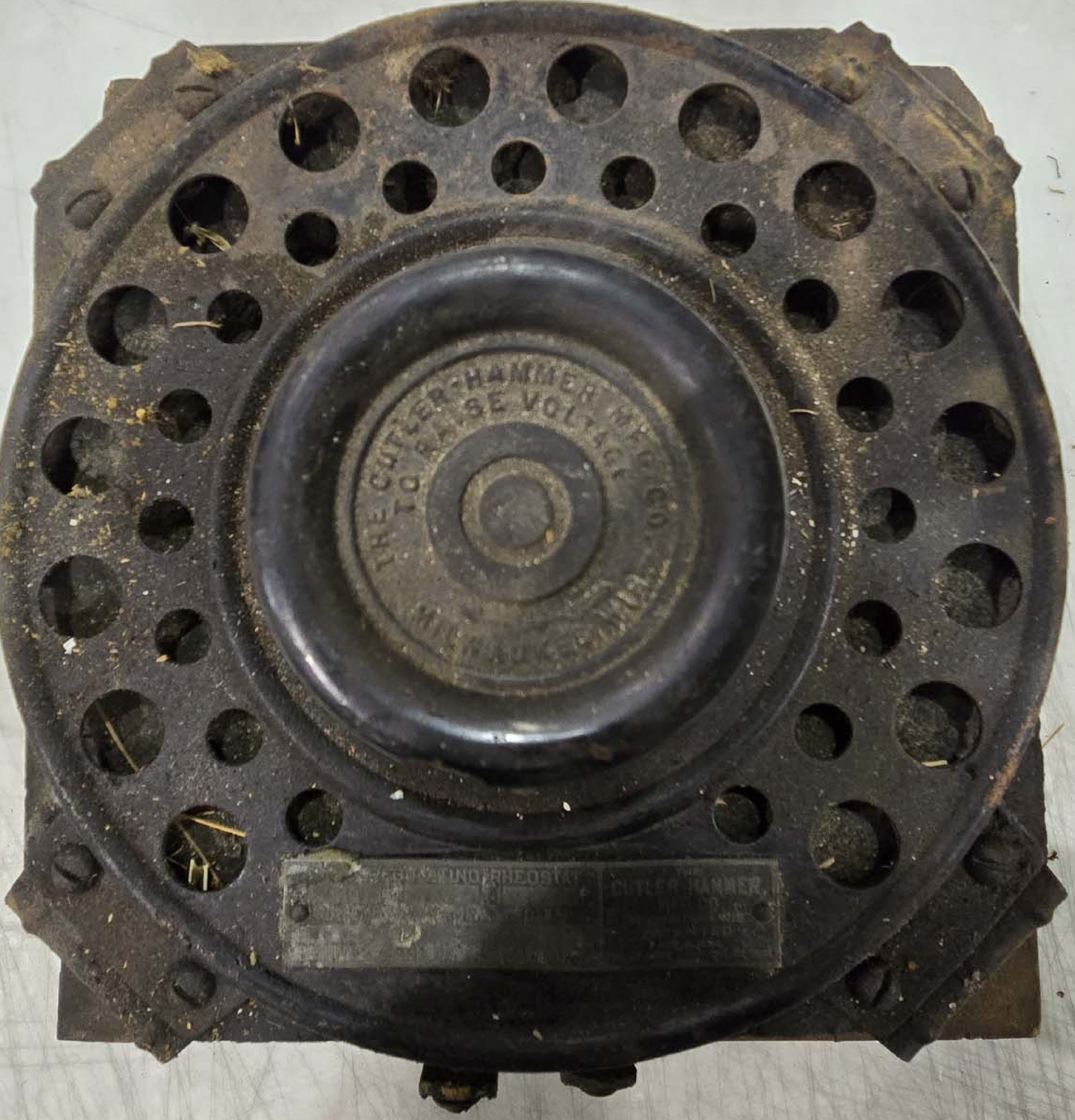
NEWARK WORKS, NEWARK, N. J., U. S. A.

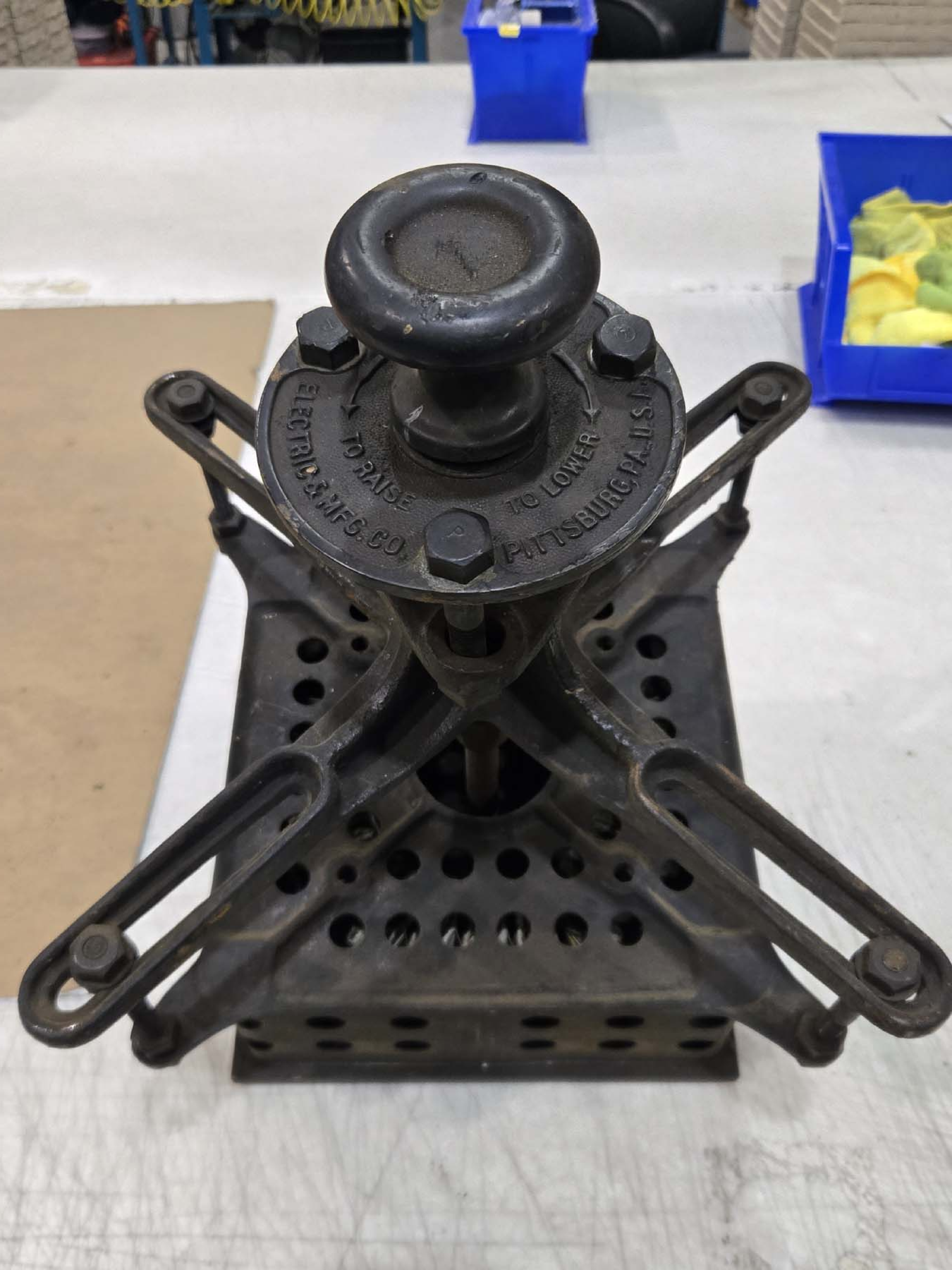

Westinghouse
RESISTOR
VOLTS
OHMS
2400
AMPERES
S.O.
198626
PAT
7-29-13
WESTINGHOUSE ELECTRIC & MFG. CO.
EAST PGH. WORKS EAST PGH. PA. U.S.A.


Westinghouse
RESISTOR
Westinghouse
RESISTOR
Westinghouse
RESISTANCE

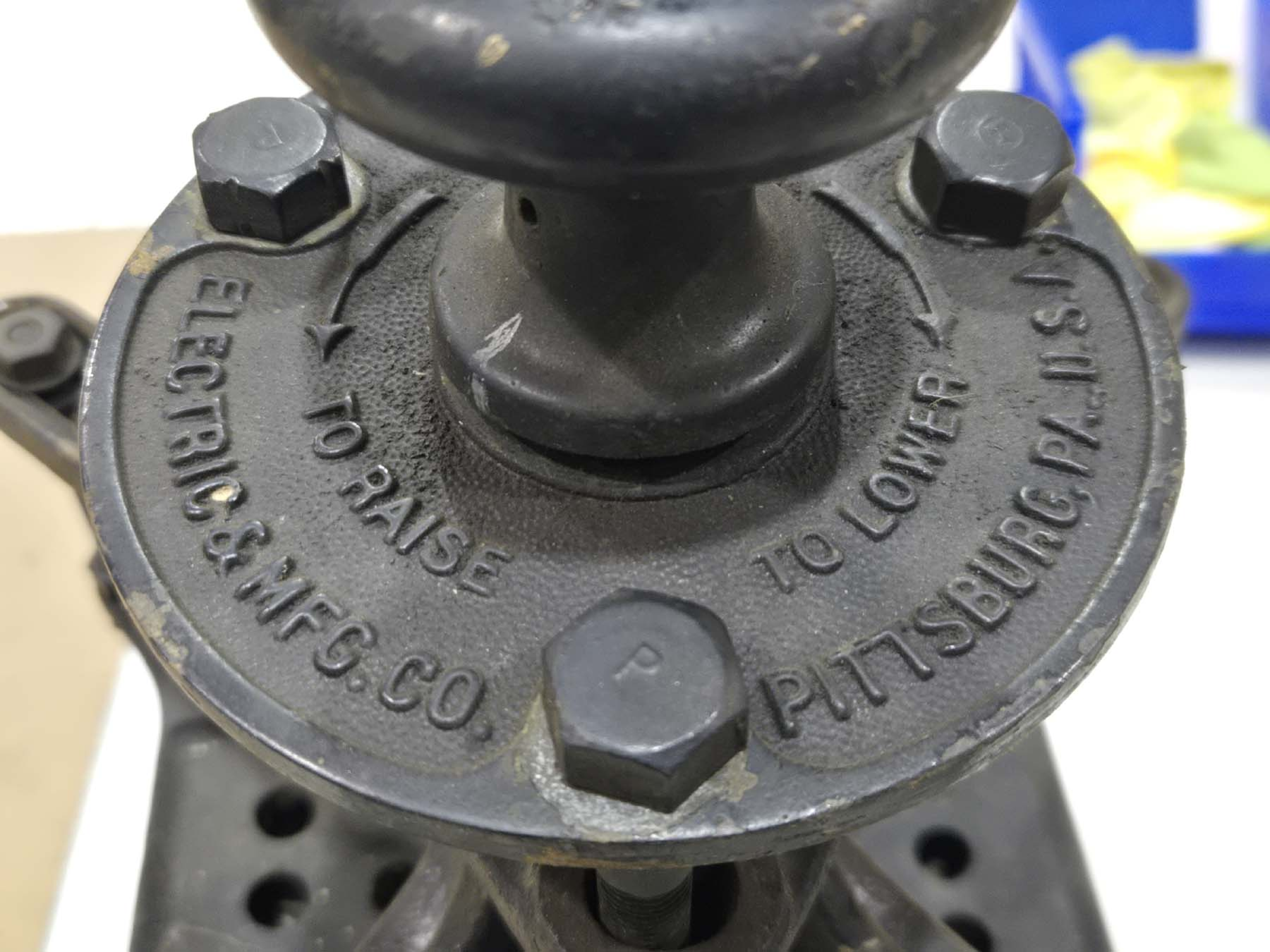

THE CUTLER-HAMMER MFG. CO.
TO RAISE VOLTAGE
MILWAUKEE, WIS.
REGULATING RHEOSTAT
VOLTS
THE
CUTLER-HAMMER
MFG. CO.
MILWAUKEE, WIS.
PATENTED
APR. 5. 1904

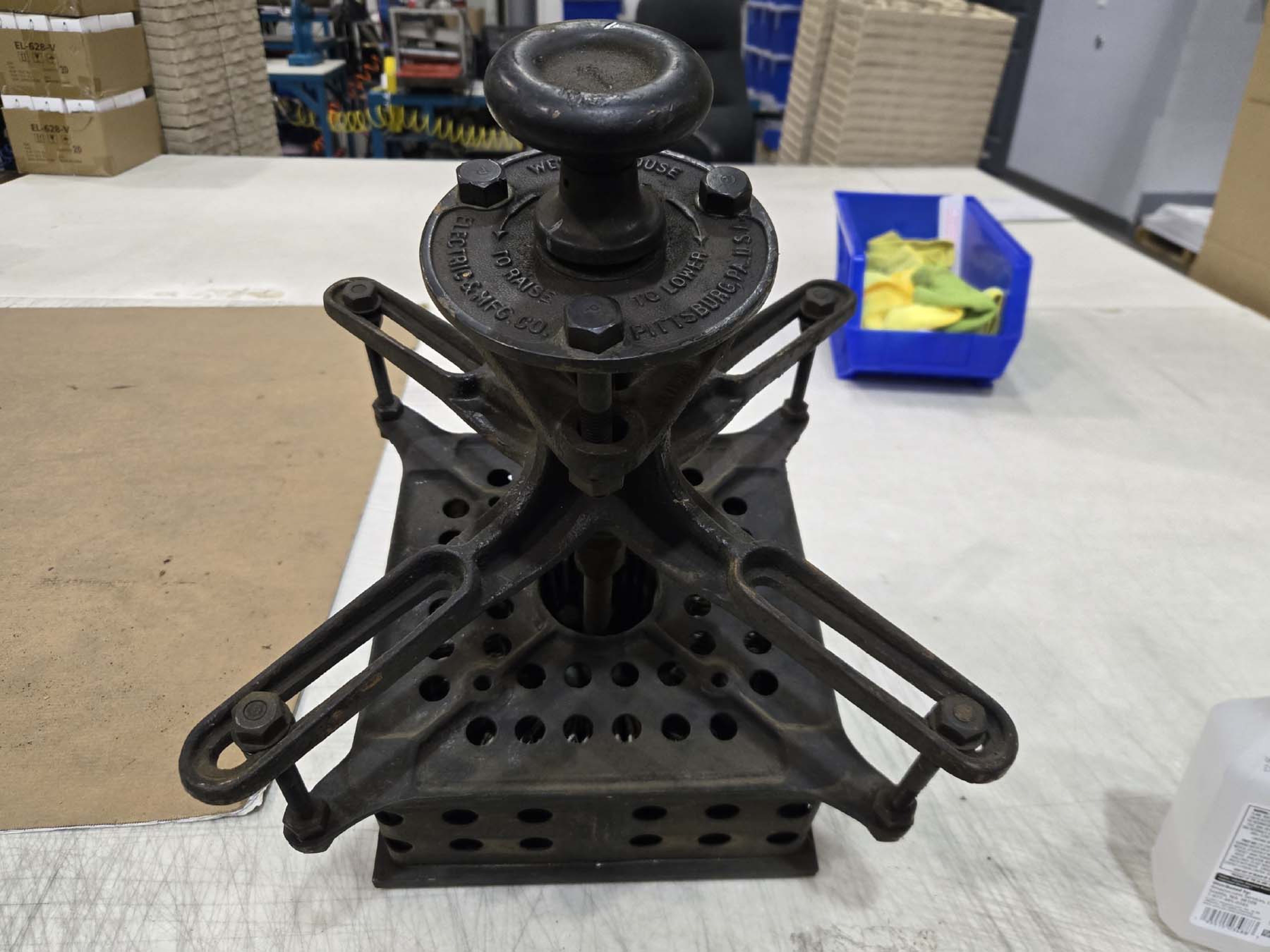

REGULATING RHEOSTAT
MAX. AMP.
MIN. AMP.
VOLTS
OHMS
CODE NO.
SERIAL NO.
THE
CUTLER-HAMMER
MFG. CO.
MILWAUKEE, WIS.
PATENTED
APR. 5, 1904
MAY 22, 1906
OCT. 22
772

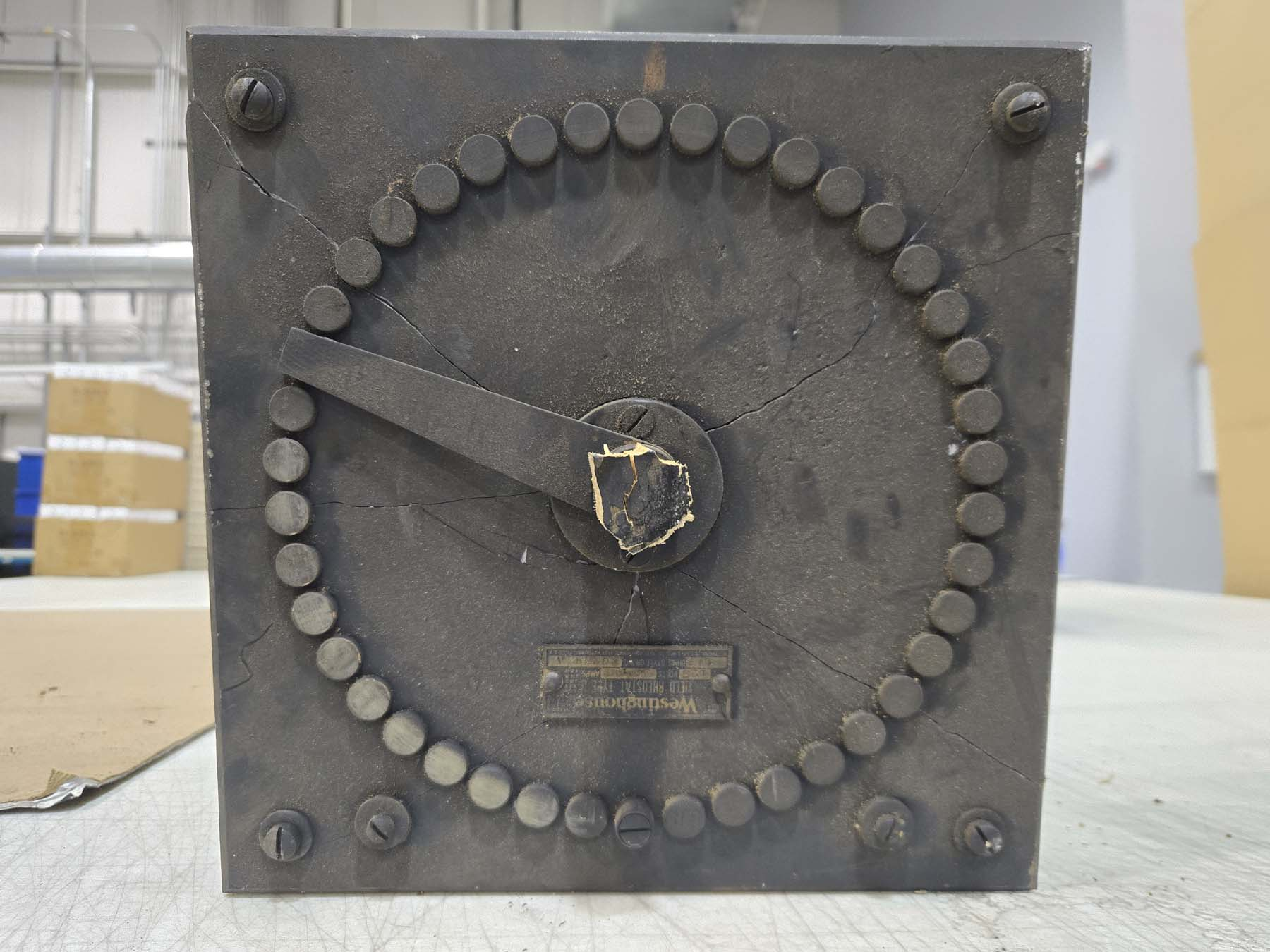

THE CUTLER-HAMMER MFG. CO.
TO RAISE VOLTAGE
MILWAUKEE, WIS.
FIELD RHEOSTAT
CUTLER-HAMMER

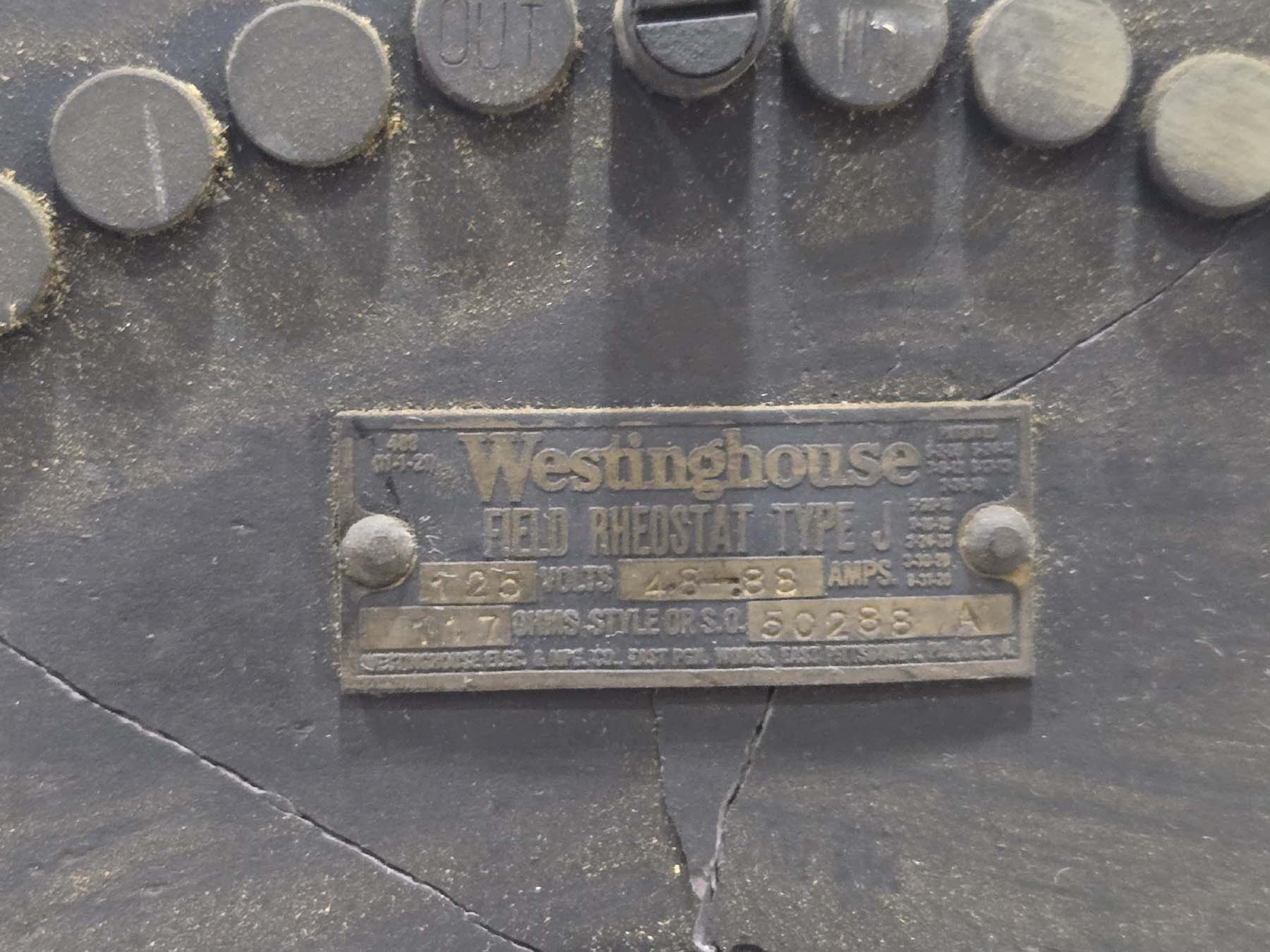

ELECTRIC & MFG. CO.
TO RAISE
TO LOWER
PITTSBURG, PA. U.S.A.

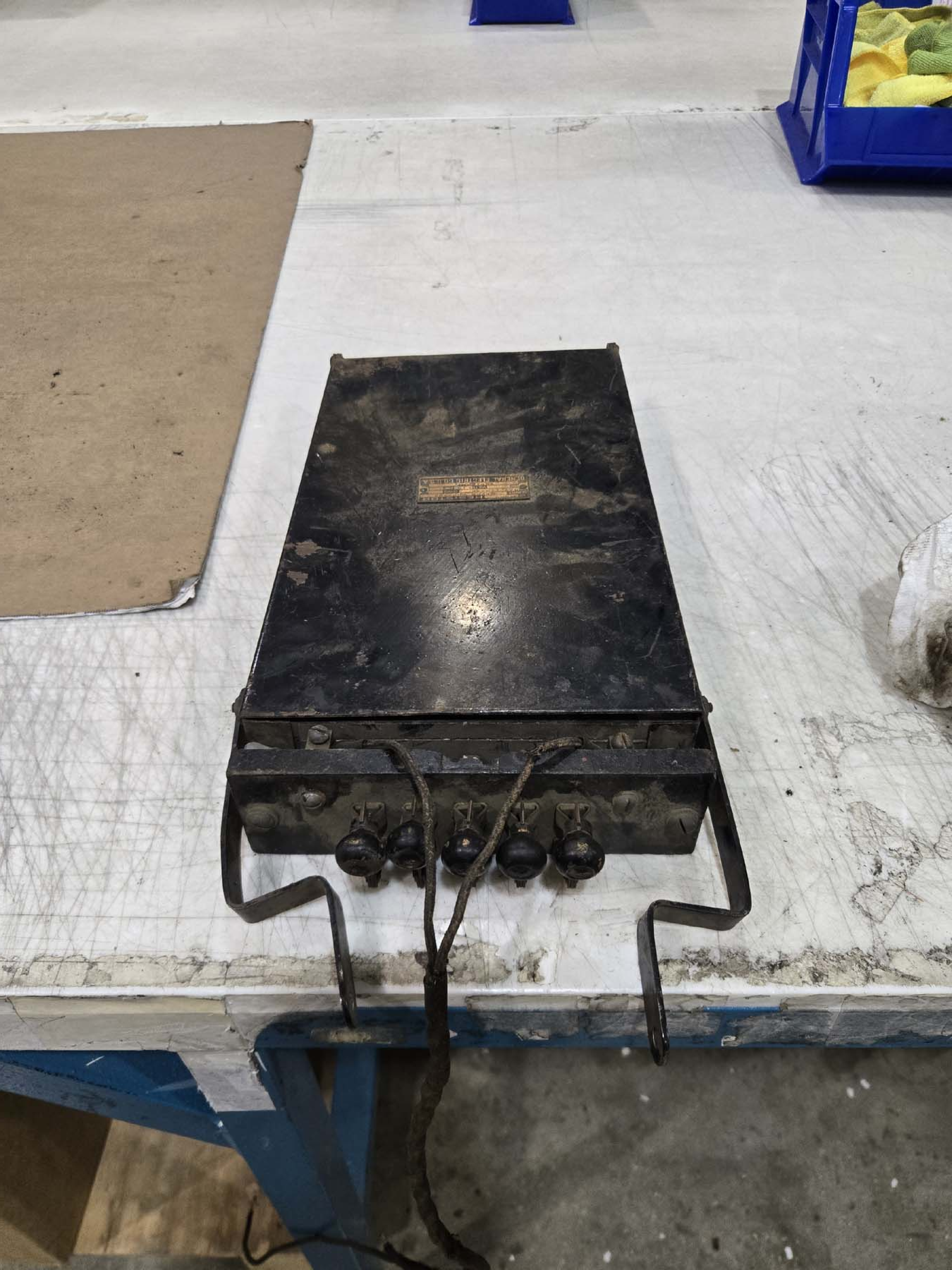
WESTINGHOUSE
VOLTAGE

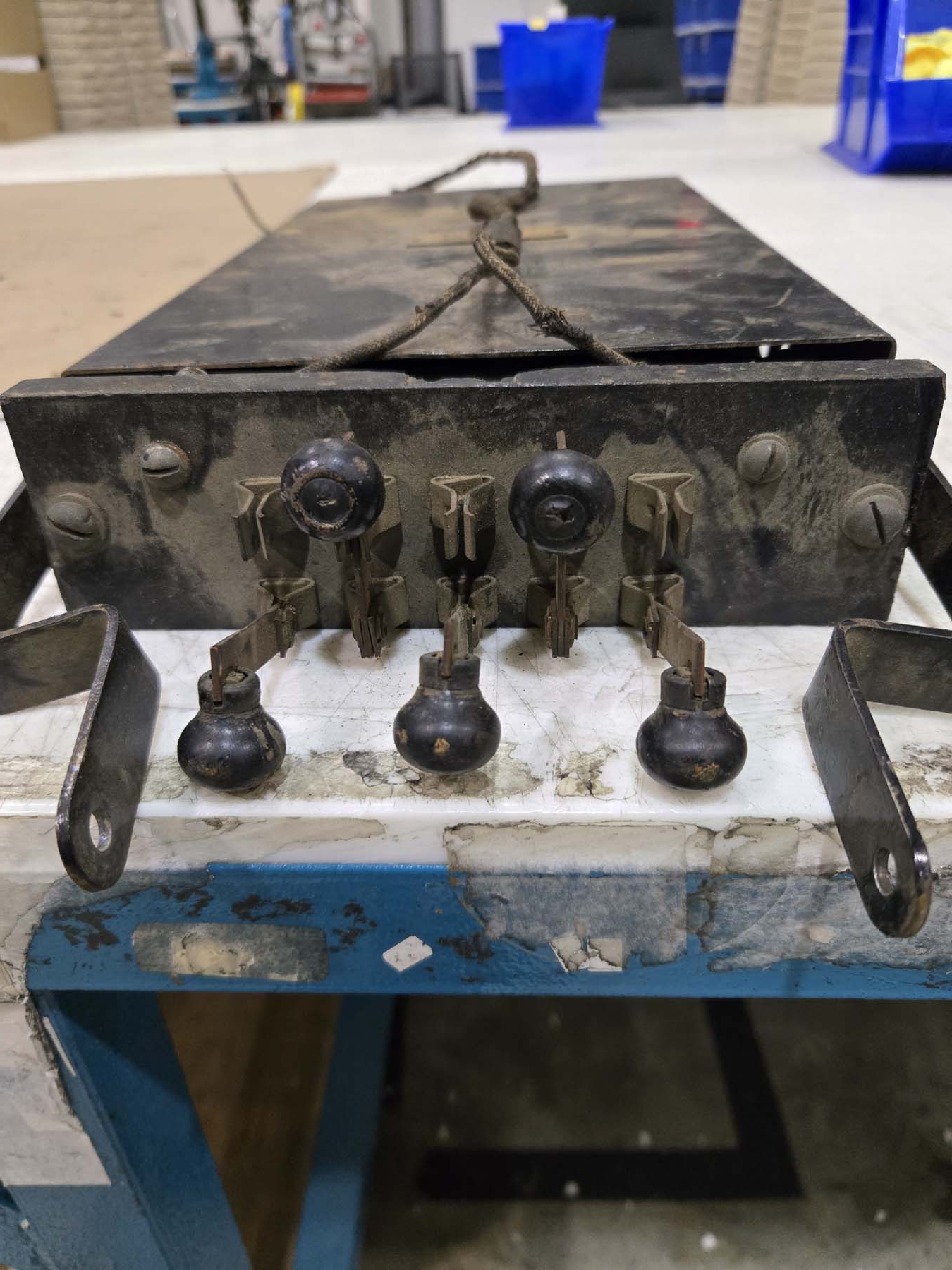

ELECTRIC & MFG. CO.
TO RAISE
TO LOWER
PITTSBURG, PA. U.S.
P

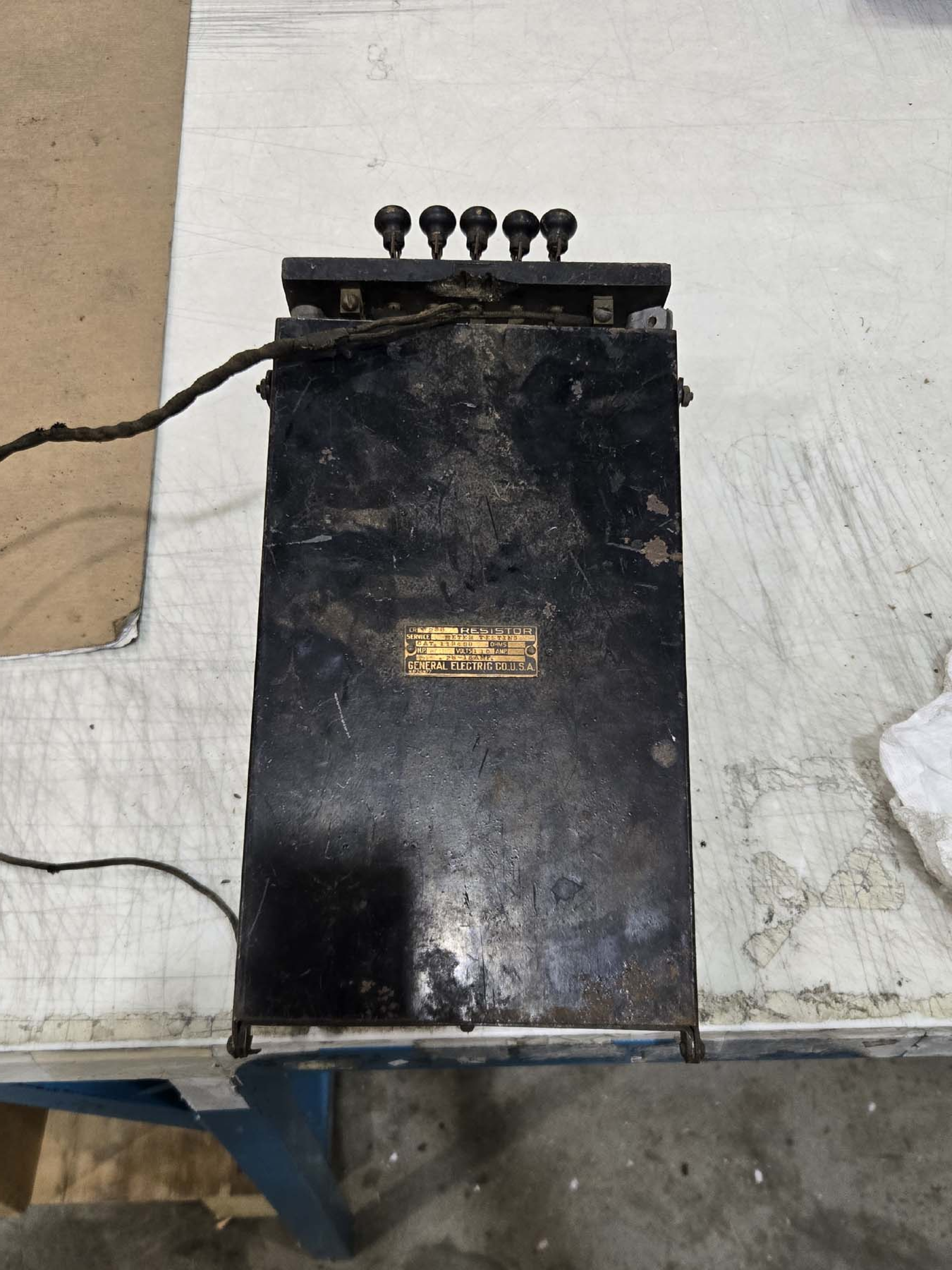

WE
OUSE
TO RAISE
TO LOWER
ELECTRIC & MFG. CO.
PITTSBURG, PA. U.S.A.
EL-628-V
EL-628-V

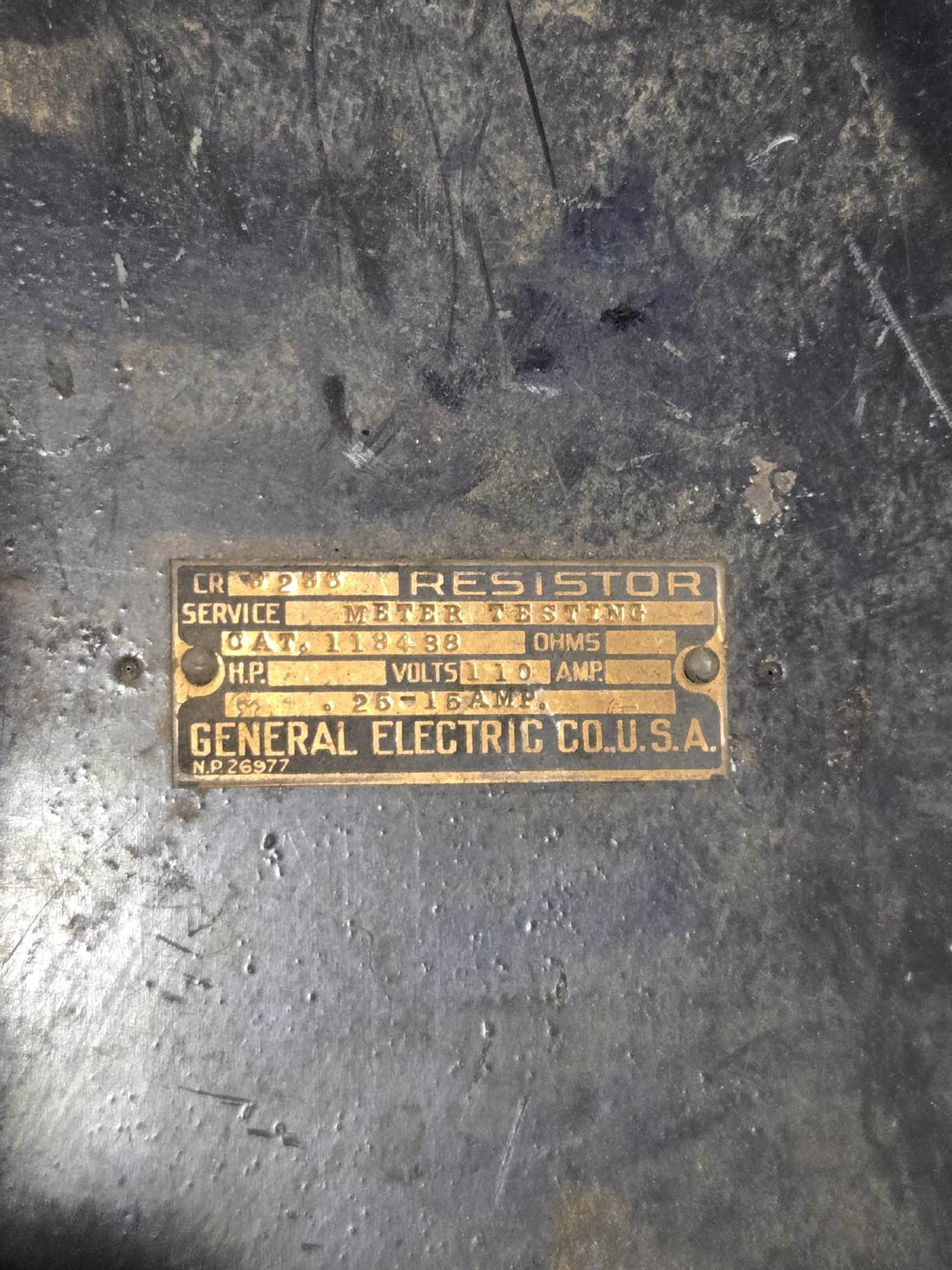

Westinghouse
FIELD RHEOSTAT TYPE


OUT
Westinghouse
FIELD RHEOSTAT TYPE J
125 VOLTS
4.8-.88 AMPS.
11.7 OHMS-STYLE OR S.O. 50288 A
WESTINGHOUSE ELEC. & MFG. CO. EAST PGH. WORKS, EAST PITTSBURGH, PA. U.S.A.

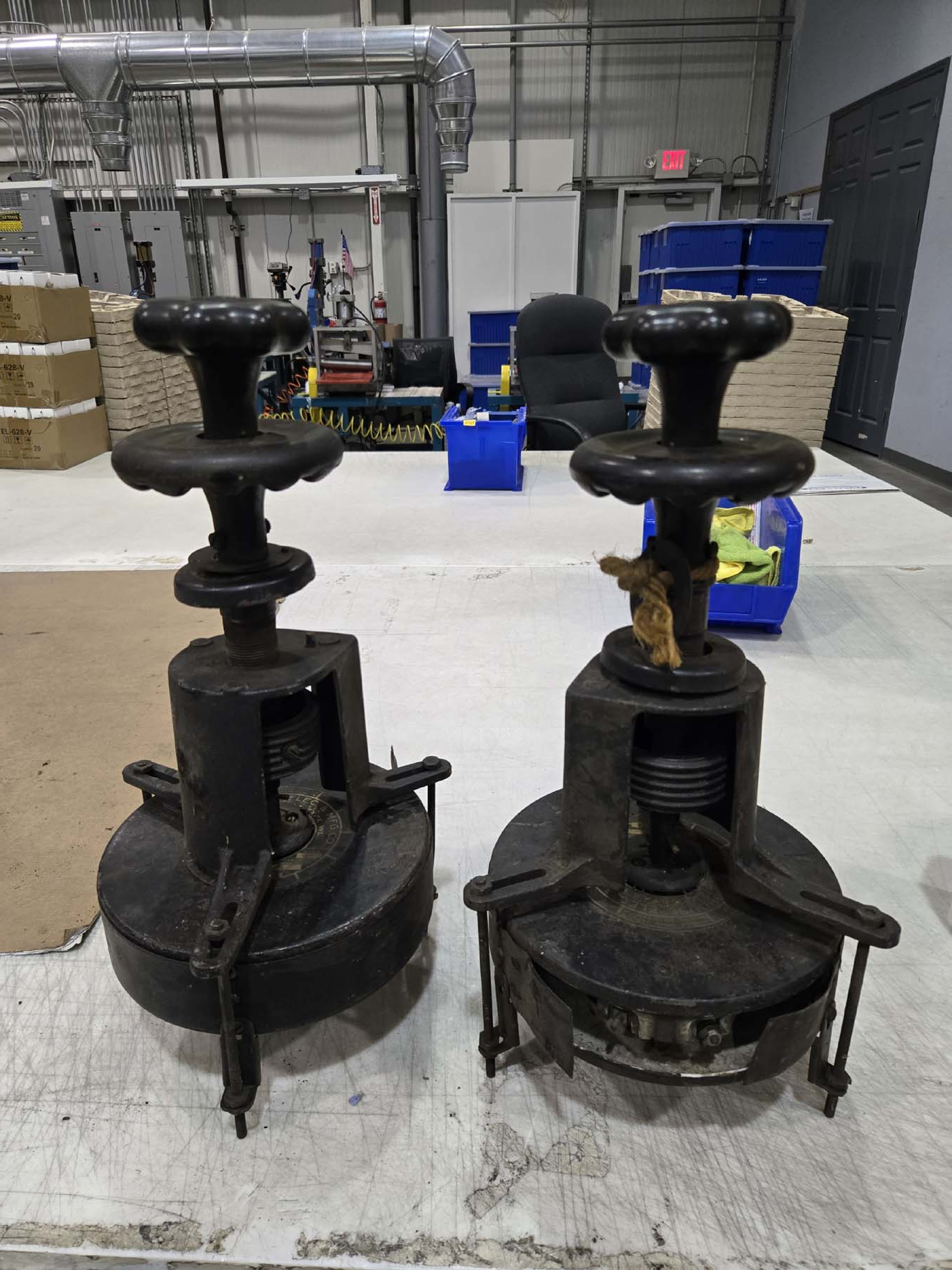





RESISTOR
SERVICE
METER TESTING
CAT.
OHMS
H.P.
VOLTS 110
AMP
GENERAL ELECTRIC CO. U.S.A.

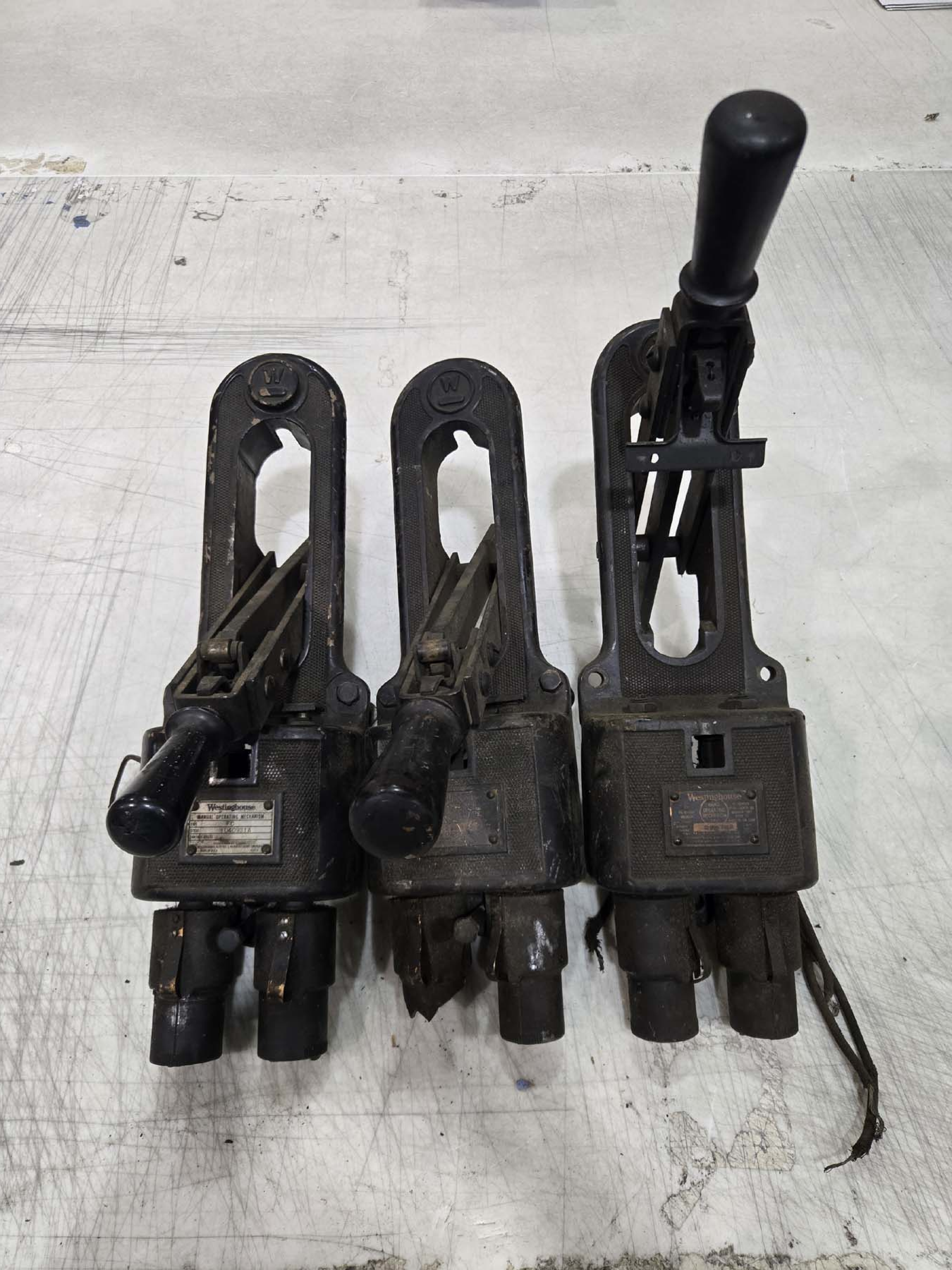


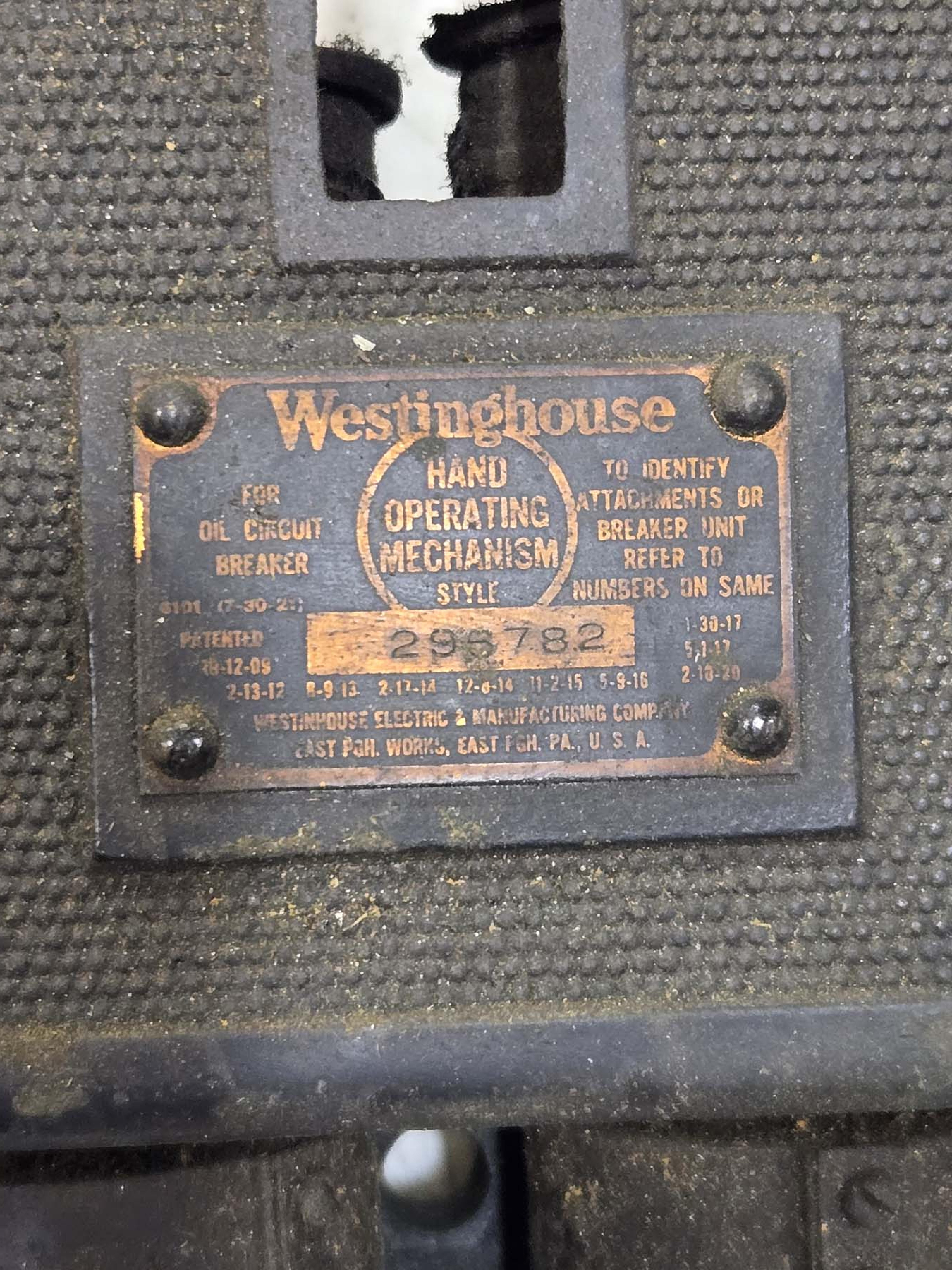
CR [illegible]298 RESISTOR
SERVICE METER TESTING
CAT. 119438 OHMS
H.P. VOLTS 110 AMP.
. 25-15 AMP.
GENERAL ELECTRIC CO. U.S.A.
N.P. 26977


EXIT
S MFG CO

STINGHOUSE ELEC.
EAST PITTSBURGH, PA. U.S.
FIELD RHEOSTAT.
SLOW SPEED FAST
HIGH VOLTS LOW

PATENTS PEND
OHMS
175
FOR USE WITH
MOTOR OR GENERATORS NO.
213914 A


Westinghouse
MANUAL OPERATING MECHANISM
FC
Westinghouse



Westinghouse

FOR
OIL CIRCUIT
BREAKER

HAND
OPERATING
MECHANISM
STYLE

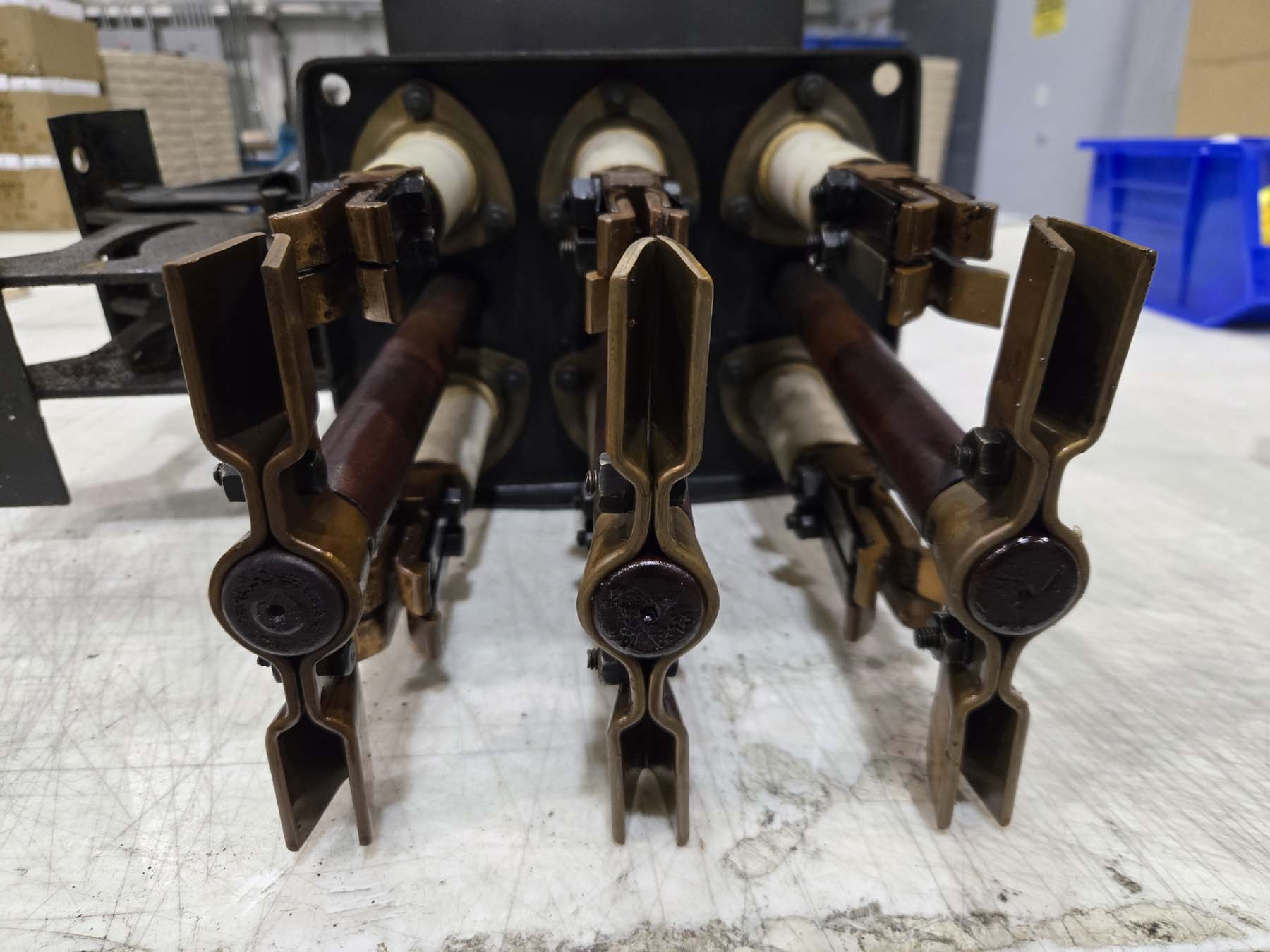
TO IDENTIFY
ATTACHMENTS OR
BREAKER UNIT
REFER TO
NUMBERS ON SAME

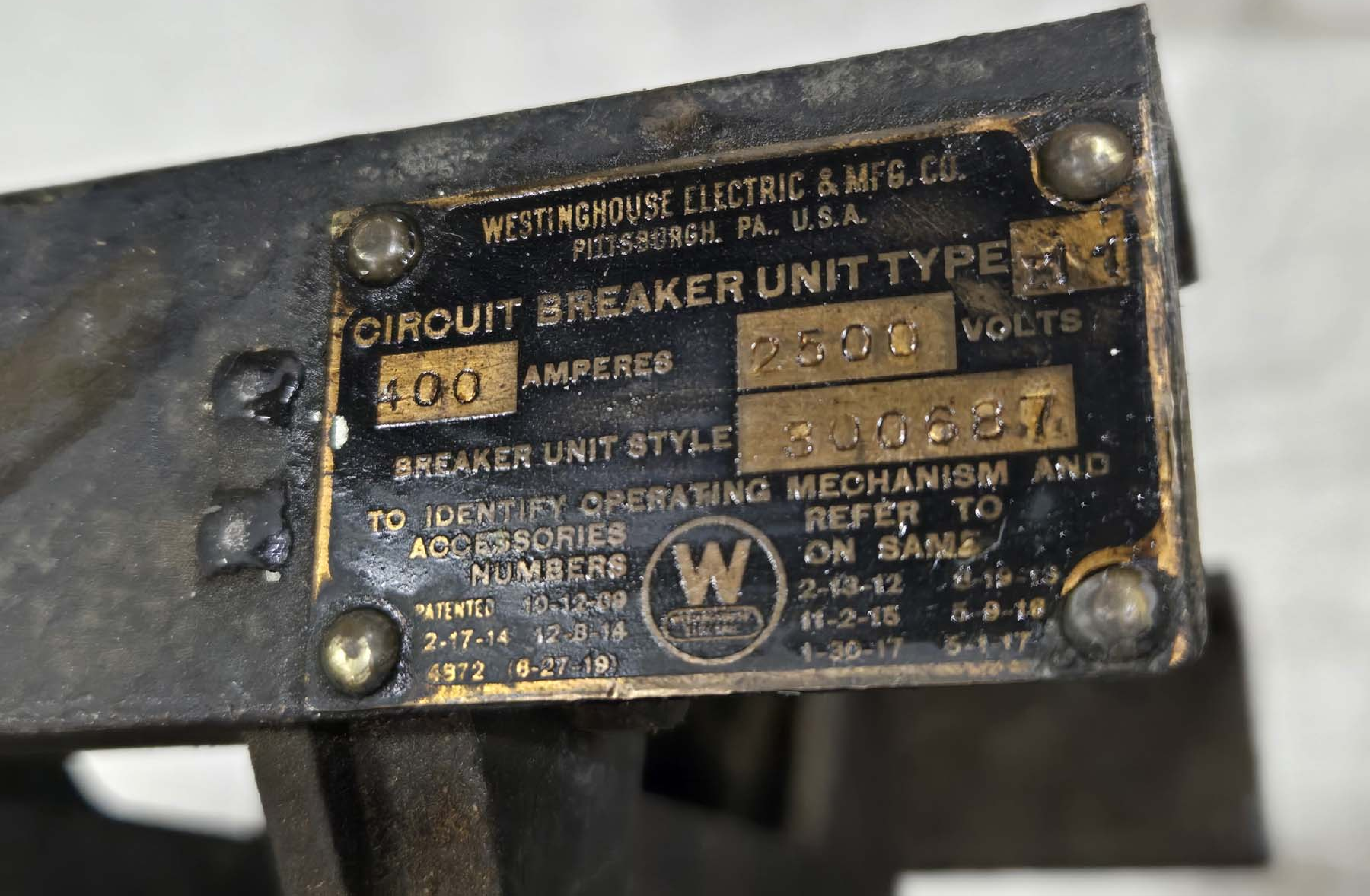
6101 (7-30-21)

295782

PATENTED
10-12-09
2-13-12 8-9-13 2-17-14 12-8-14 11-2-15 5-9-16
1-30-17
5-1-17
2-10-20

WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY
EAST PGH. WORKS, EAST PGH. PA., U. S. A.





WESTINGHOUSE ELECTRIC & MFG. CO.
PITTSBURGH. PA. U.S.A.

CIRCUIT BREAKER UNIT TYPE H 1

400 AMPERES

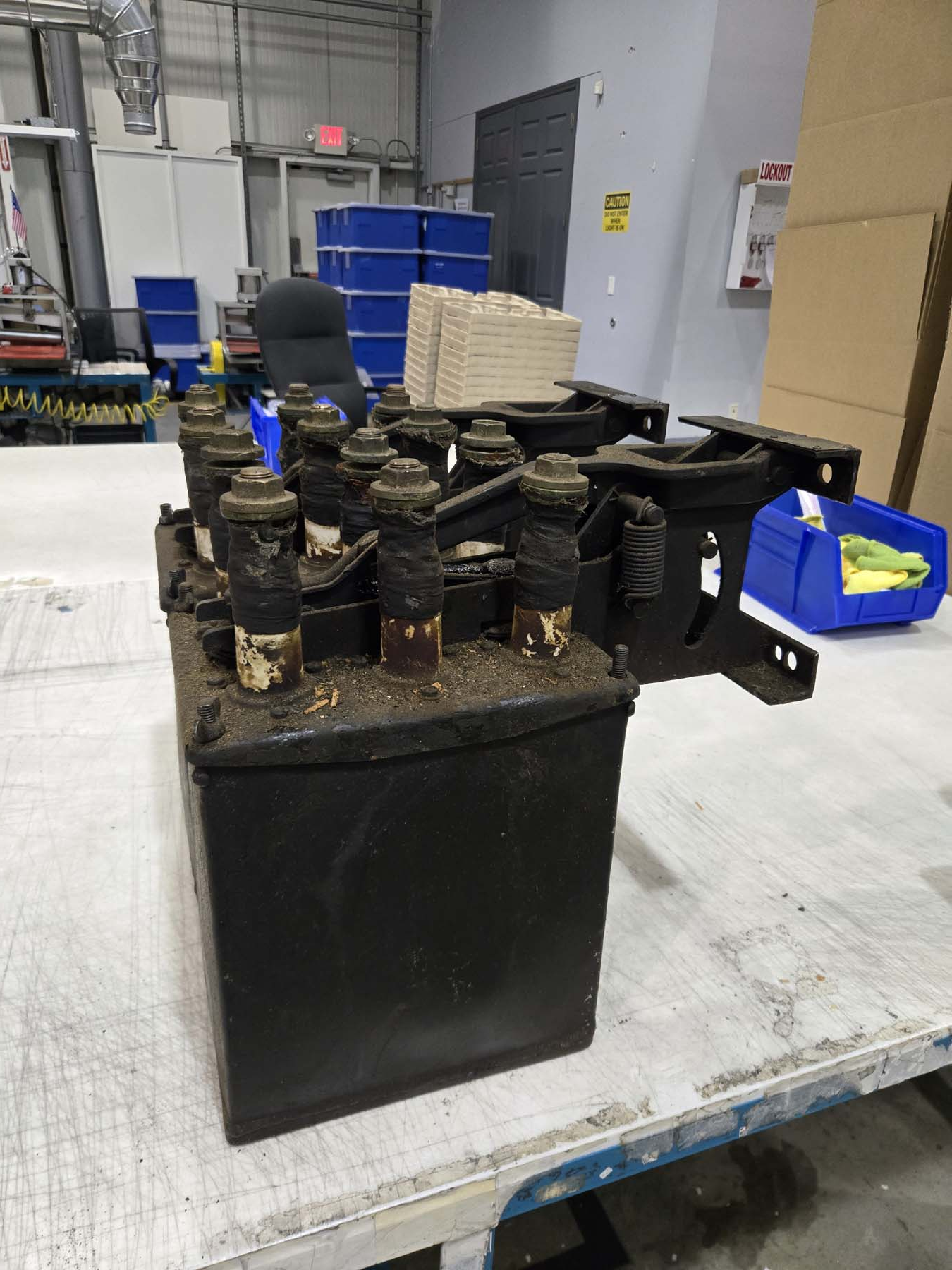
2500 VOLTS

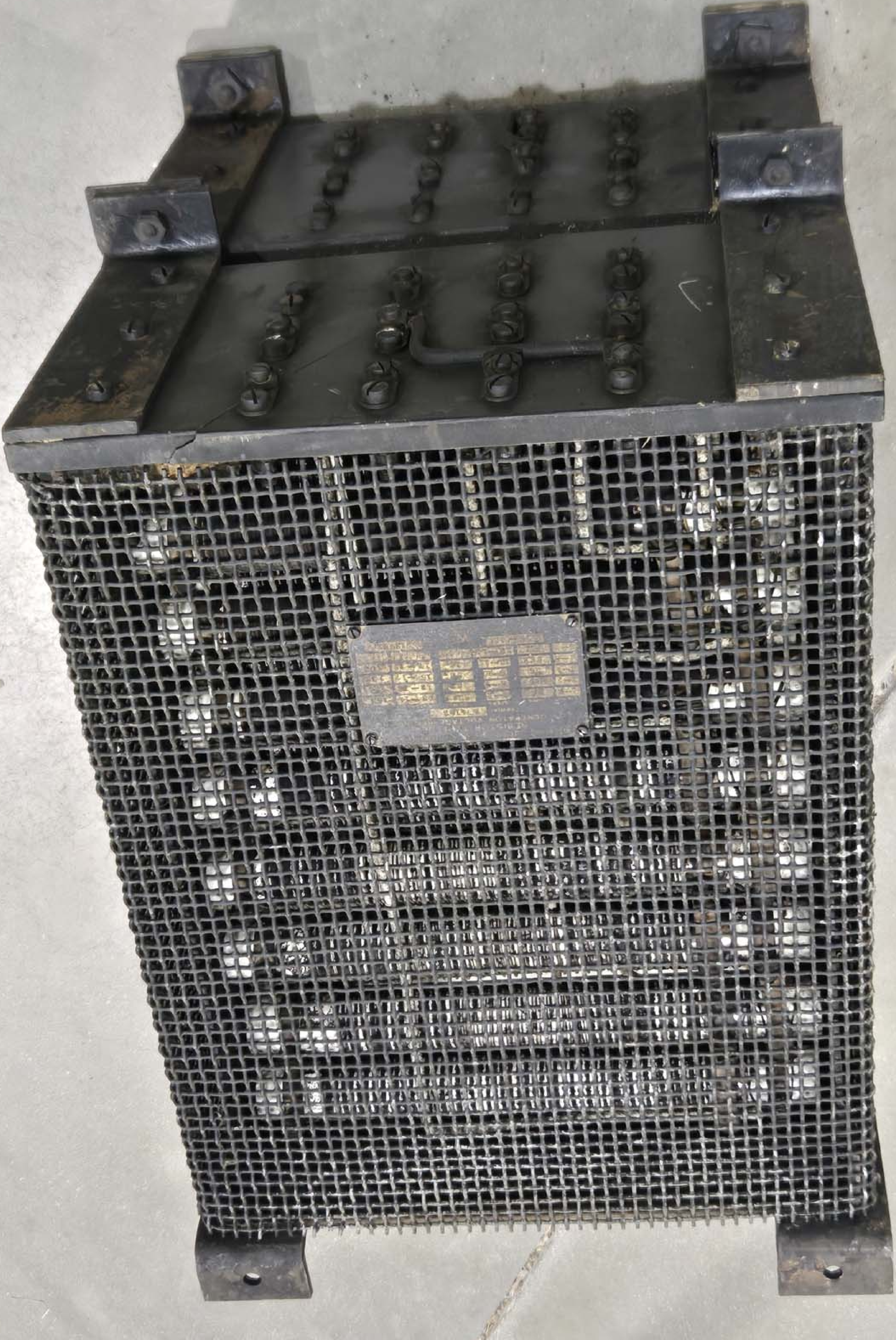
BREAKER UNIT STYLE 300687

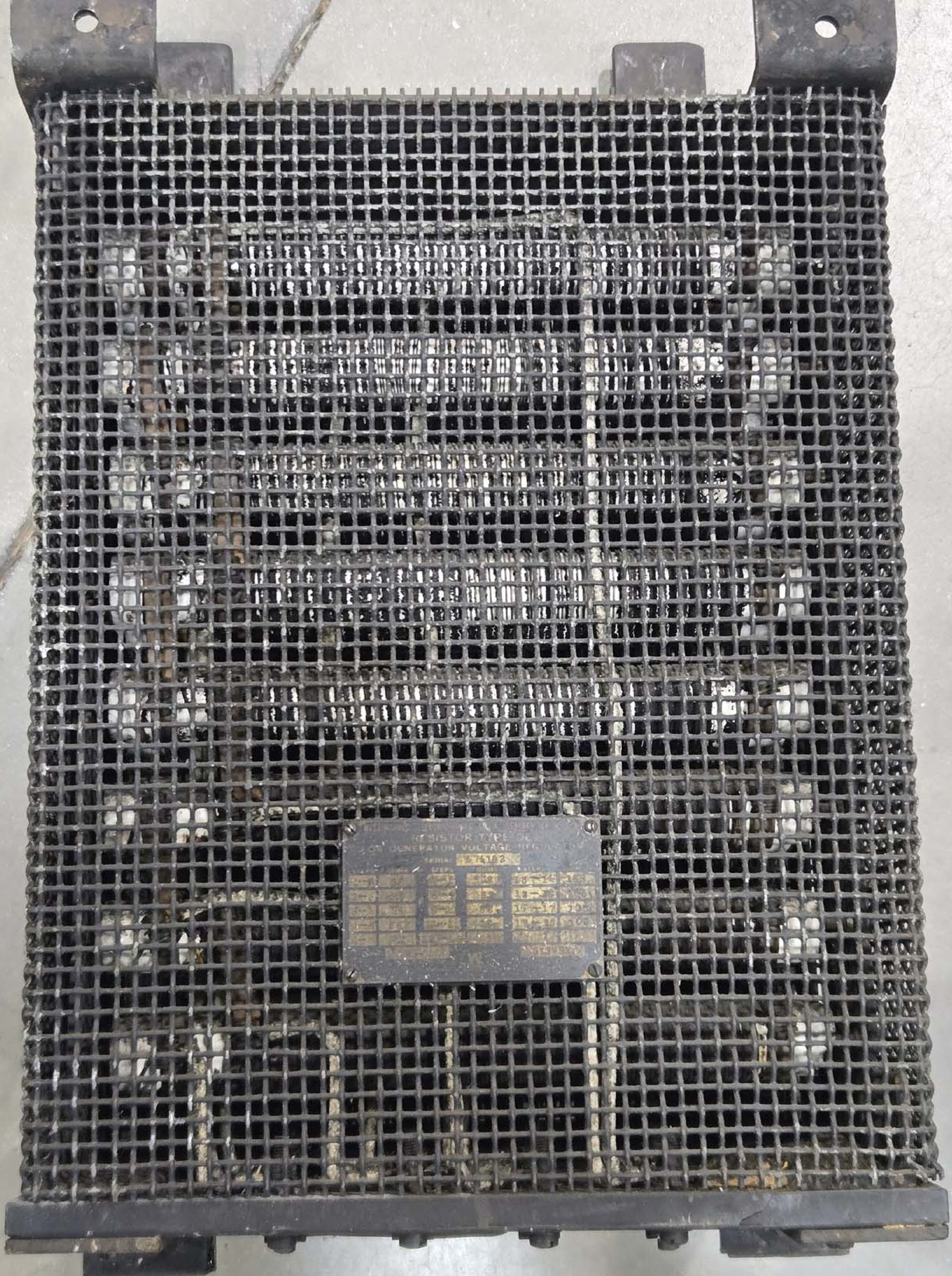
TO IDENTIFY OPERATING MECHANISM AND ACCESSORIES REFER TO NUMBERS ON SAME

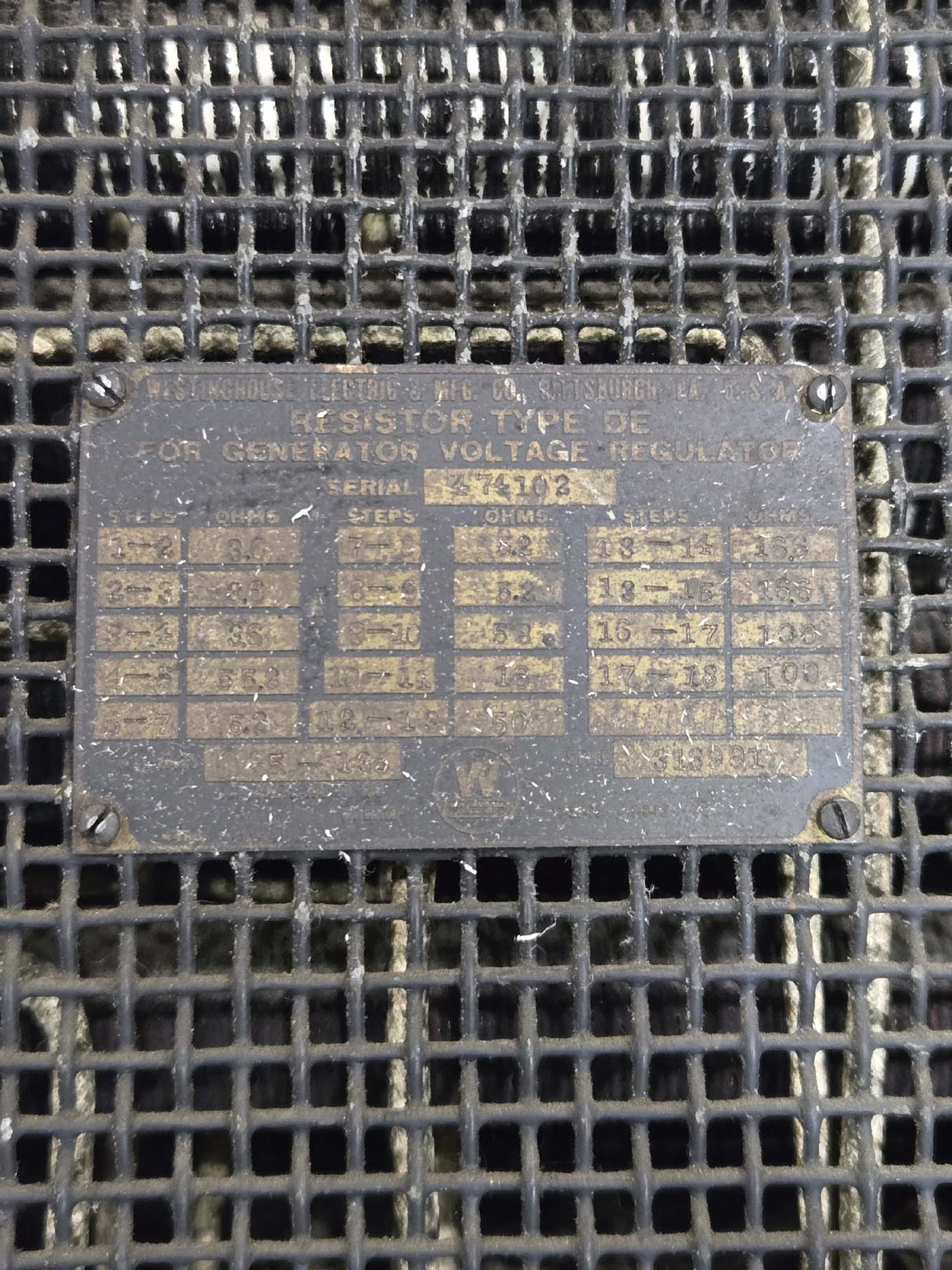
PATENTED 10-12-09
2-17-14 12-8-14
4972 (6-27-19)

2-13-12 4-19-13
11-2-15 5-9-16
1-30-17 5-1-17


EXIT
CAUTION
DO NOT ENTER
WHEN
LIGHT IS ON
LOCKOUT




RESISTOR TYPE DC
FOR GENERATOR VOLTAGE
SERIAL



WESTINGHOUSE ELECTRIC & MFG. CO., PITTSBURGH, PA. U.S.A.

RESISTOR TYPE DE

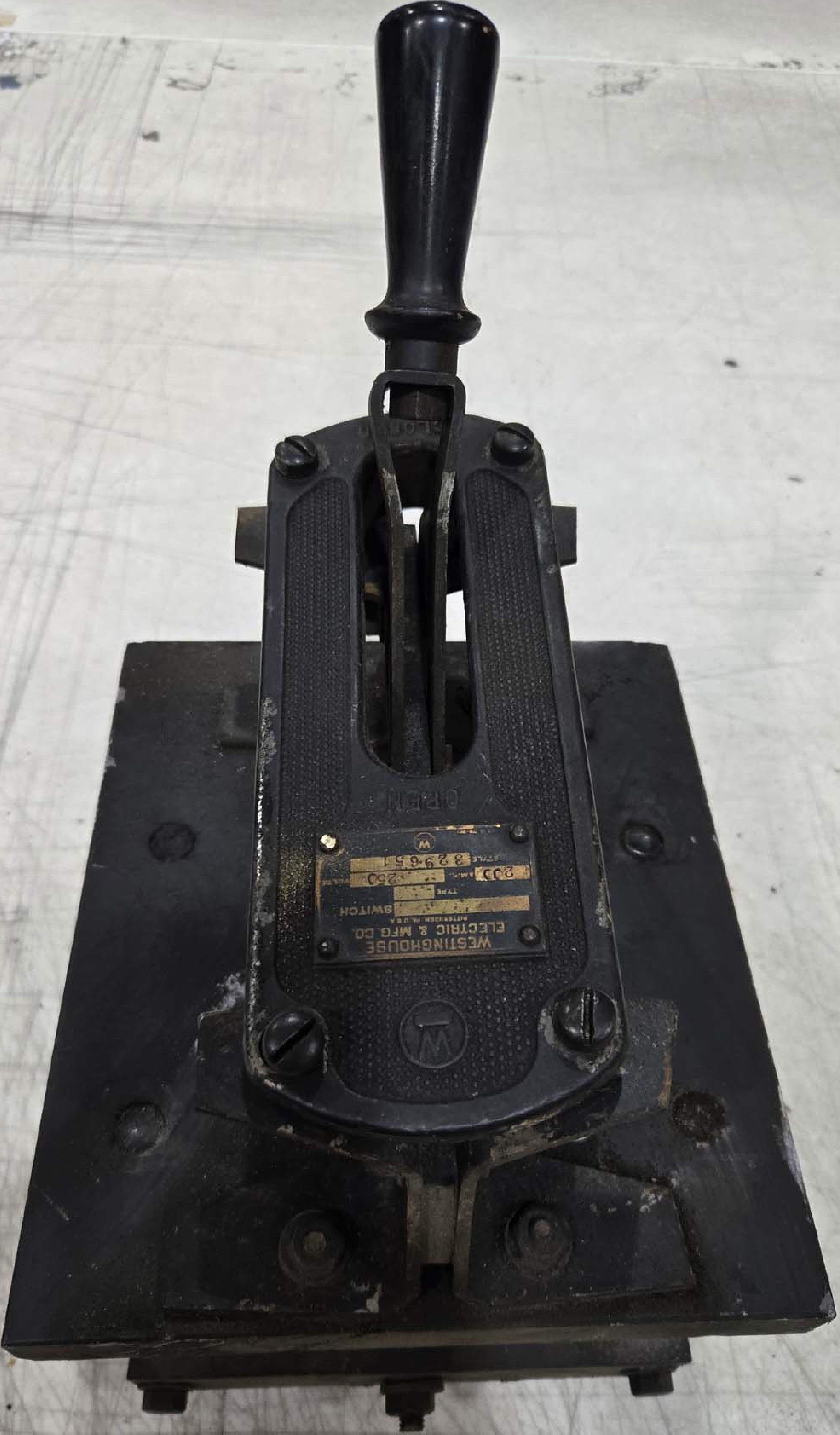
FOR GENERATOR VOLTAGE REGULATOR

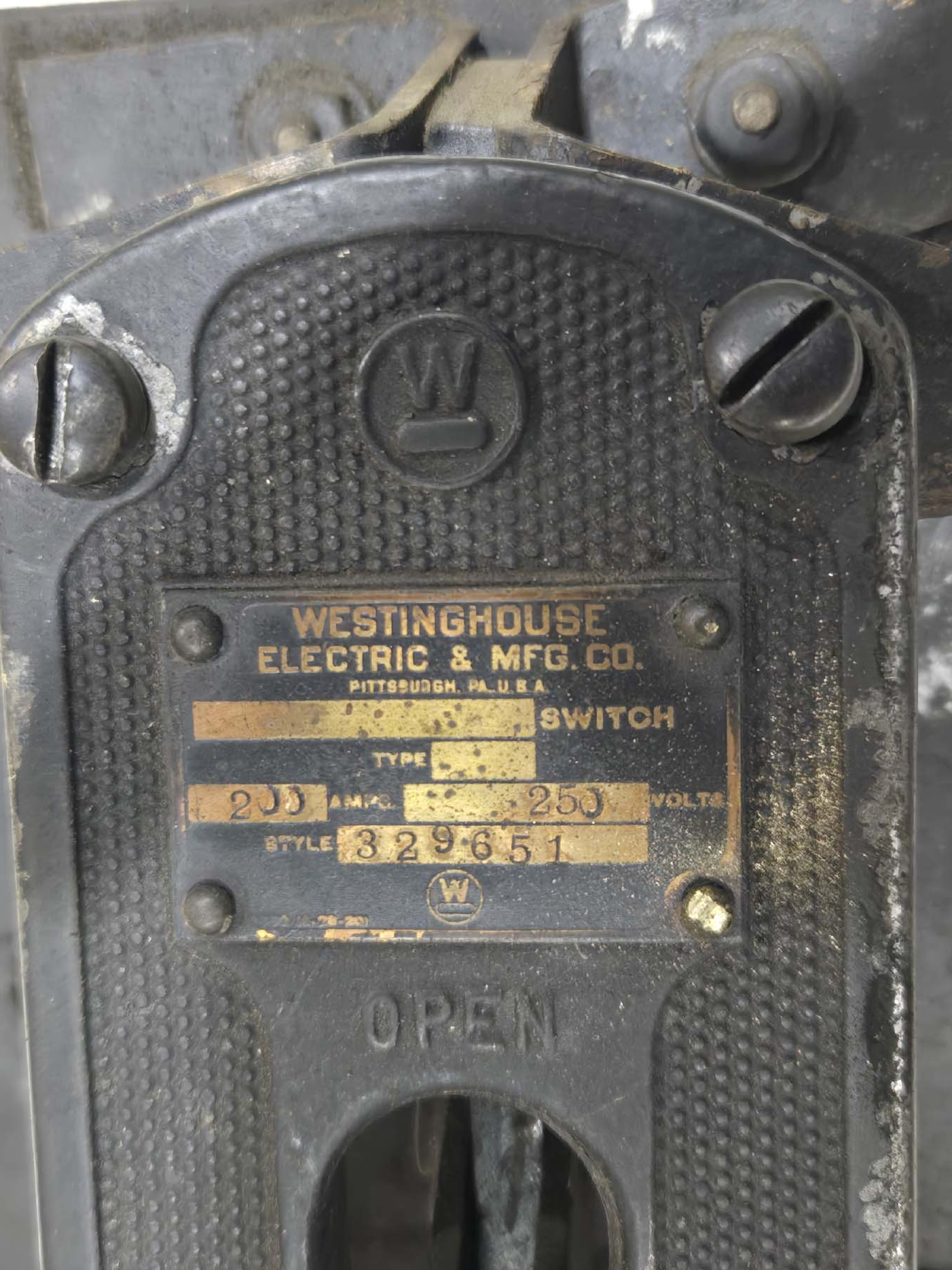
SERIAL 474102

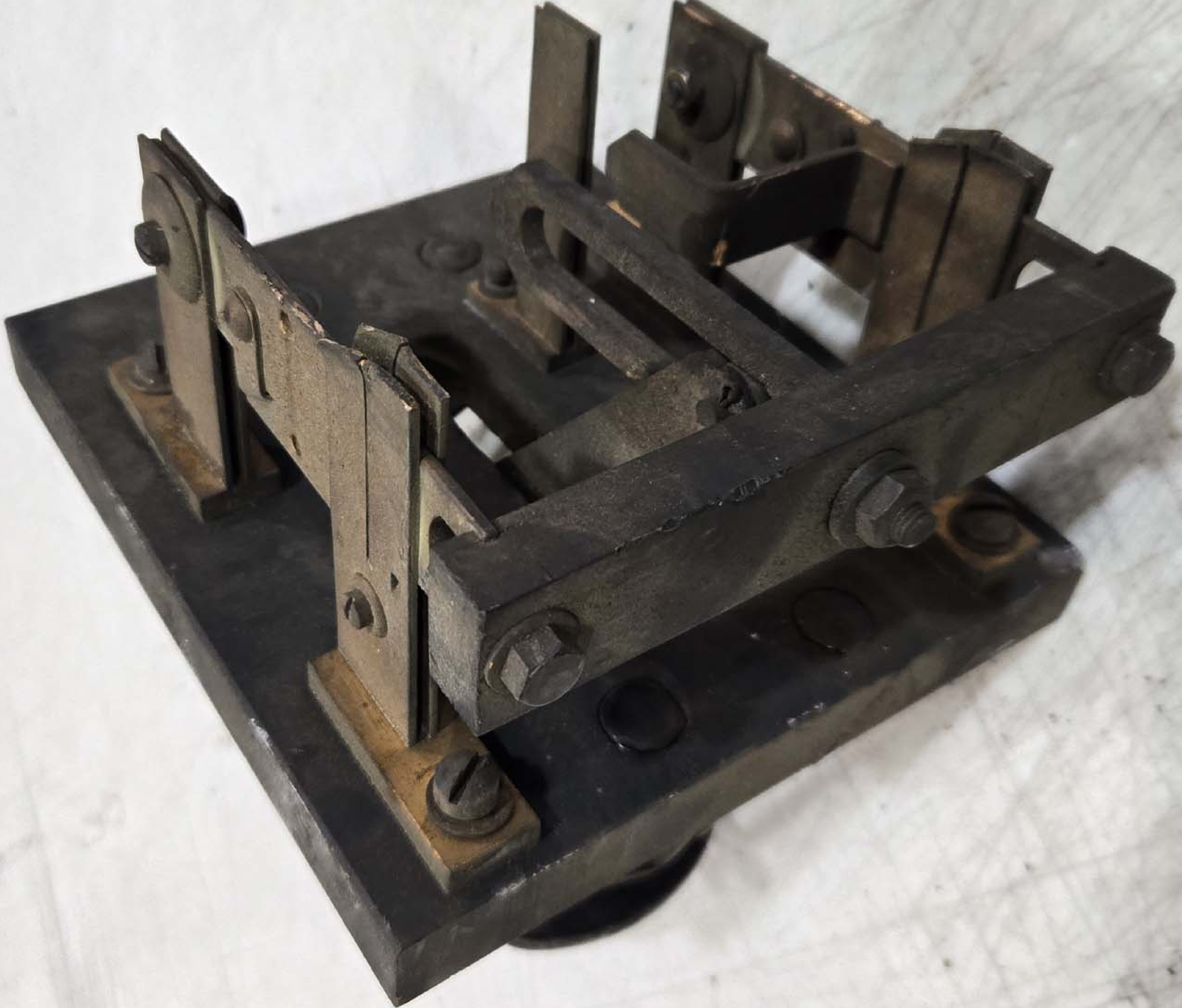
STEPS	OHMS	STEPS	OHMS	STEPS	OHMS
1—2	3.6	7—8	5.2	13—14	16.6
2—3	3.8	8—9	5.2	13—15	16.6
3—4	36	9—10	5.8	16—17	106
4—5	55.8	10—11	16	17—18	100
5—7	5.2	12—13	50		

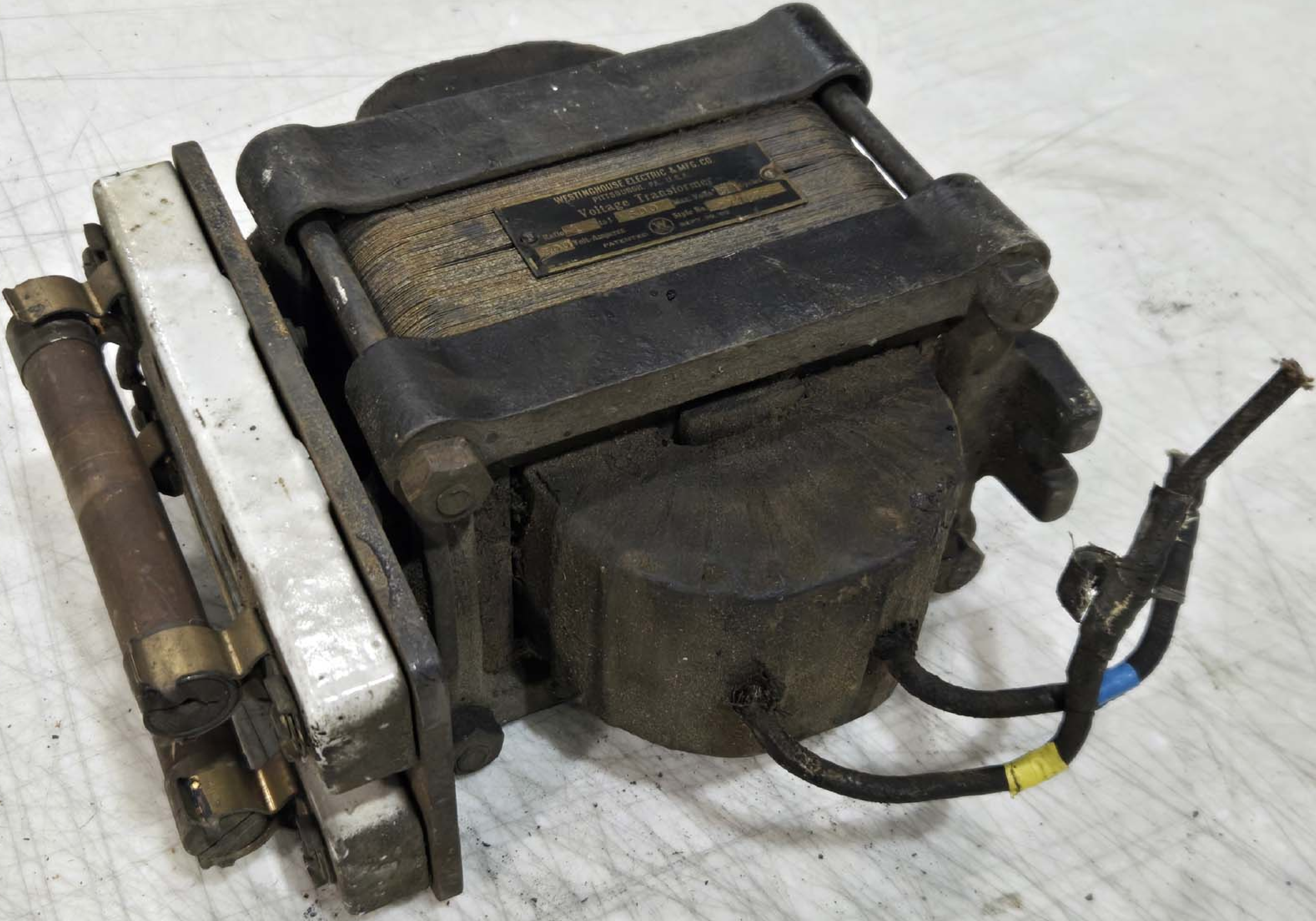
5 — 135

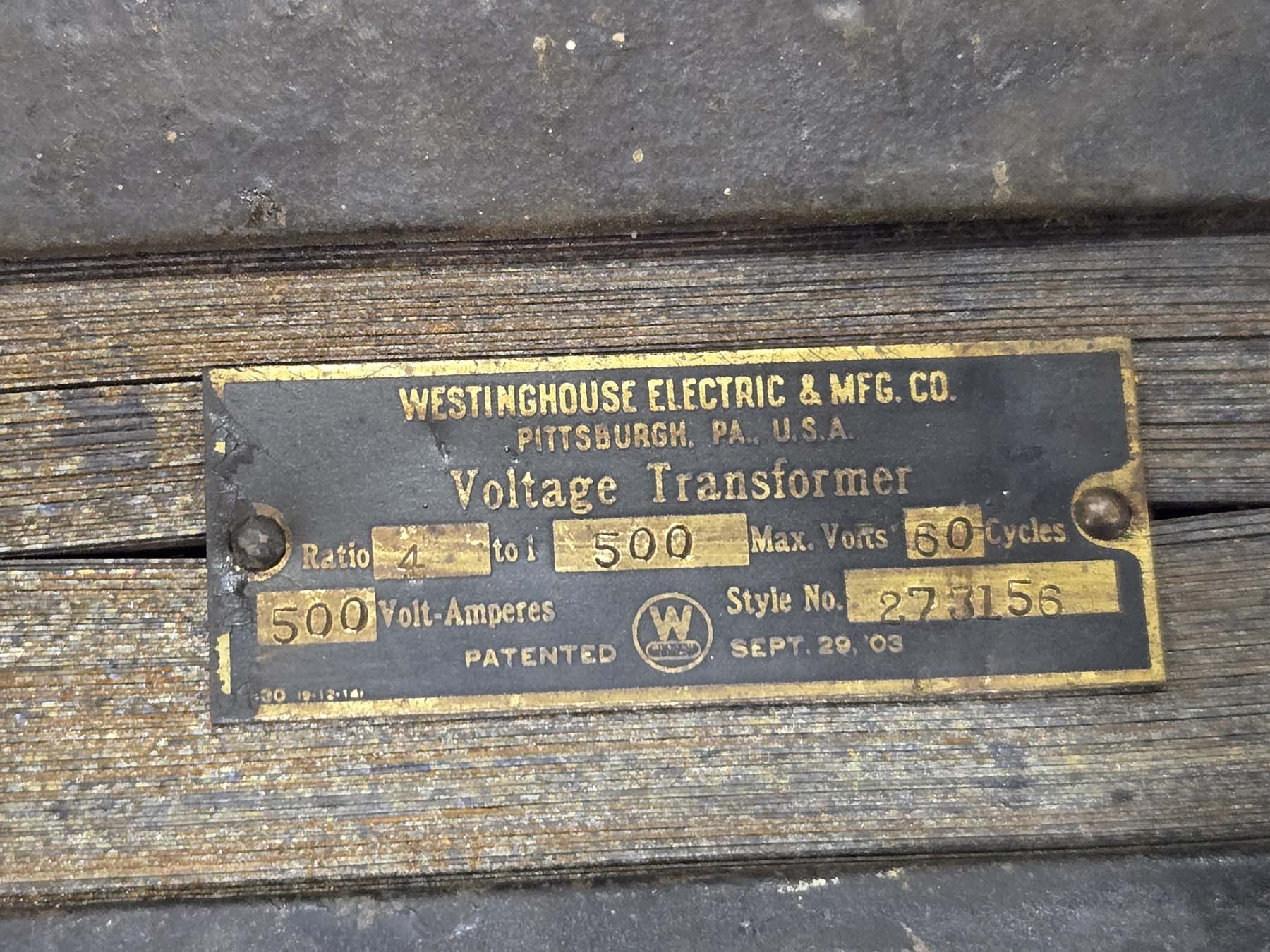
S.O. 313991


CLOSED
OPEN
STYLE 329651
AMP. 200
VOLTS 250
TYPE
SWITCH
PITTSBURGH, PA. U.S.A.
ELECTRIC & MFG. CO.
WESTINGHOUSE


WESTINGHOUSE
ELECTRIC & MFG. CO.
PITTSBURGH, PA. U.S.A.
SWITCH
TYPE
200 AMPS.
250 VOLTS
STYLE 329651
OPEN




WESTINGHOUSE ELECTRIC & MFG. CO
PITTSBURGH, PA. U.S.A.
Voltage Transformer
Ratio
to 1
Volt-Amperes
Style No.
PATENTED



WESTINGHOUSE ELECTRIC & MFG. CO.
PITTSBURGH, PA., U.S.A.

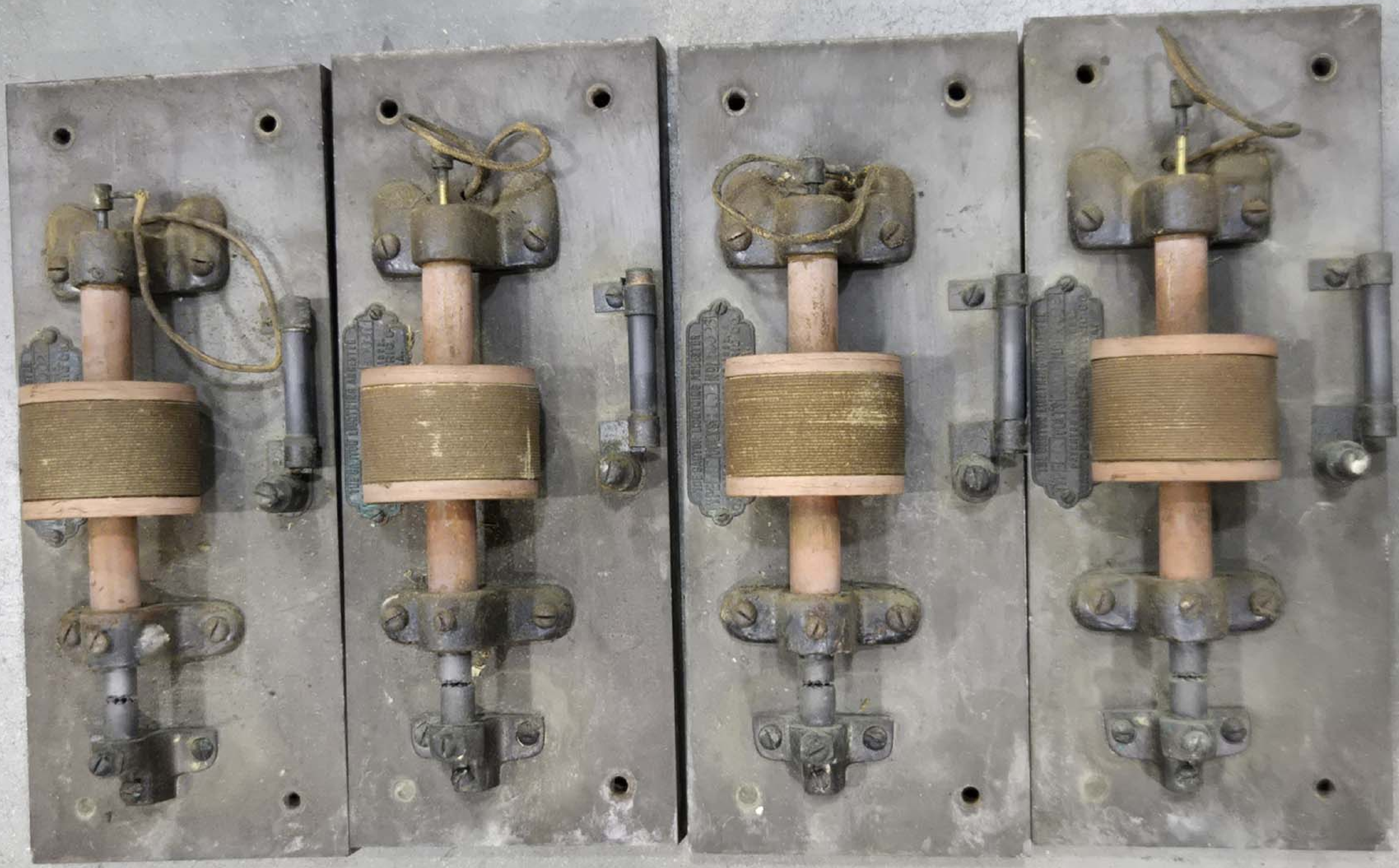
Voltage Transformer

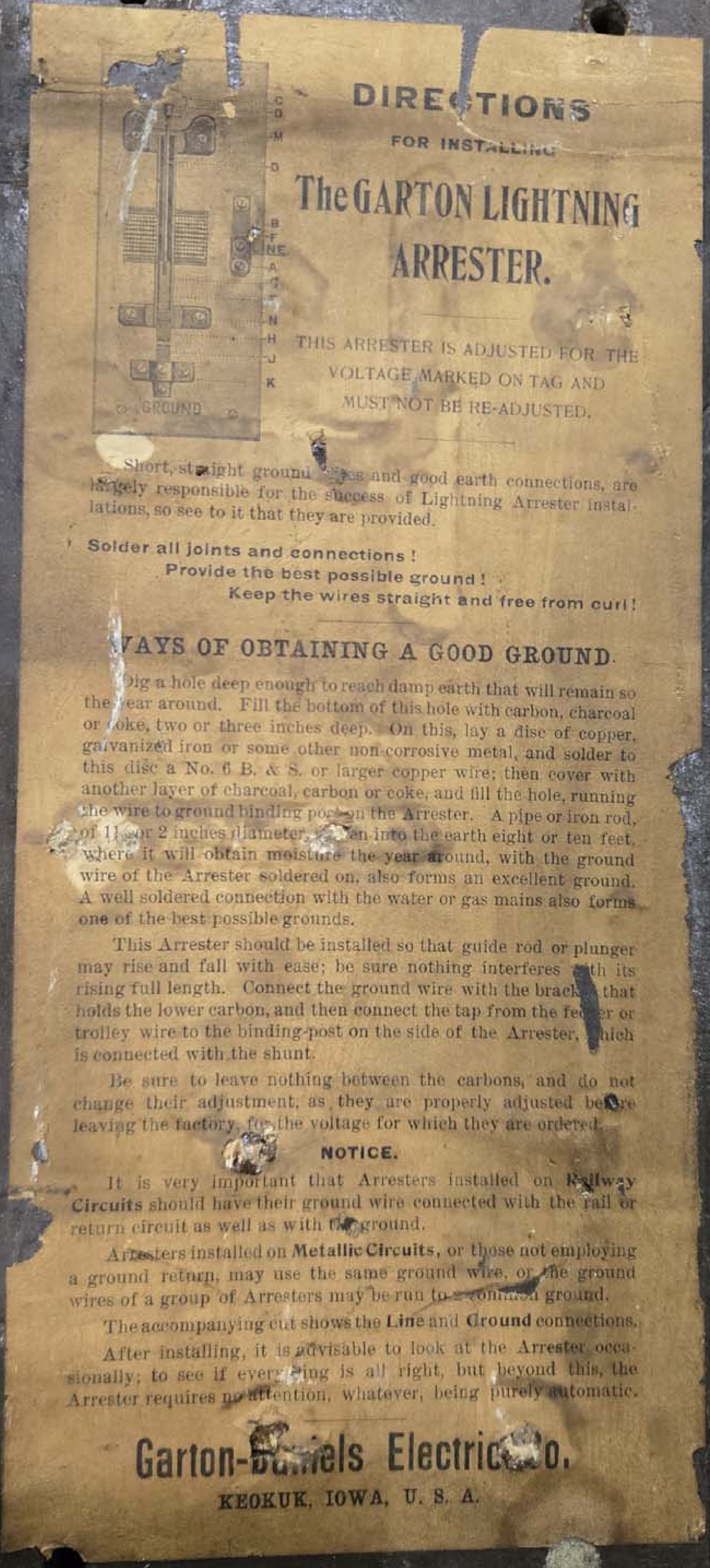
Ratio 4 to 1 500 Max. Volts 60 Cycles

500 Volt-Amperes Style No. 273156

PATENTED SEPT. 29, '03

30 (9-12-14)




C
D
M
D
B
F
LINE
A
N
H
J
K
GROUND

DIRECTIONS

FOR INSTALLING

The GARTON LIGHTNING ARRESTER.

THIS ARRESTER IS ADJUSTED FOR THE
VOLTAGE MARKED ON TAG AND
MUST NOT BE RE-ADJUSTED.

Short, straight ground wires and good earth connections, are largely responsible for the success of Lightning Arrester installations, so see to it that they are provided.

Solder all joints and connections !
Provide the best possible ground !
Keep the wires straight and free from curl !

WAYS OF OBTAINING A GOOD GROUND.

Dig a hole deep enough to reach damp earth that will remain so the year around. Fill the bottom of this hole with carbon, charcoal or coke, two or three inches deep. On this, lay a disc of copper, galvanized iron or some other non-corrosive metal, and solder to this disc a No. 6 B. & S. or larger copper wire; then cover with another layer of charcoal, carbon or coke, and fill the hole, running the wire to ground binding post on the Arrester. A pipe or iron rod, of 1½ or 2 inches diameter, driven into the earth eight or ten feet, where it will obtain moisture the year around, with the ground wire of the Arrester soldered on, also forms an excellent ground. A well soldered connection with the water or gas mains also forms one of the best possible grounds.

This Arrester should be installed so that guide rod or plunger may rise and fall with ease; be sure nothing interferes with its rising full length. Connect the ground wire with the bracket that holds the lower carbon, and then connect the tap from the feeder or trolley wire to the binding-post on the side of the Arrester, which is connected with the shunt.

Be sure to leave nothing between the carbons, and do not change their adjustment, as they are properly adjusted before leaving the factory, for the voltage for which they are ordered.

NOTICE.

It is very important that Arresters installed on **Railway Circuits** should have their ground wire connected with the rail or return circuit as well as with the ground.

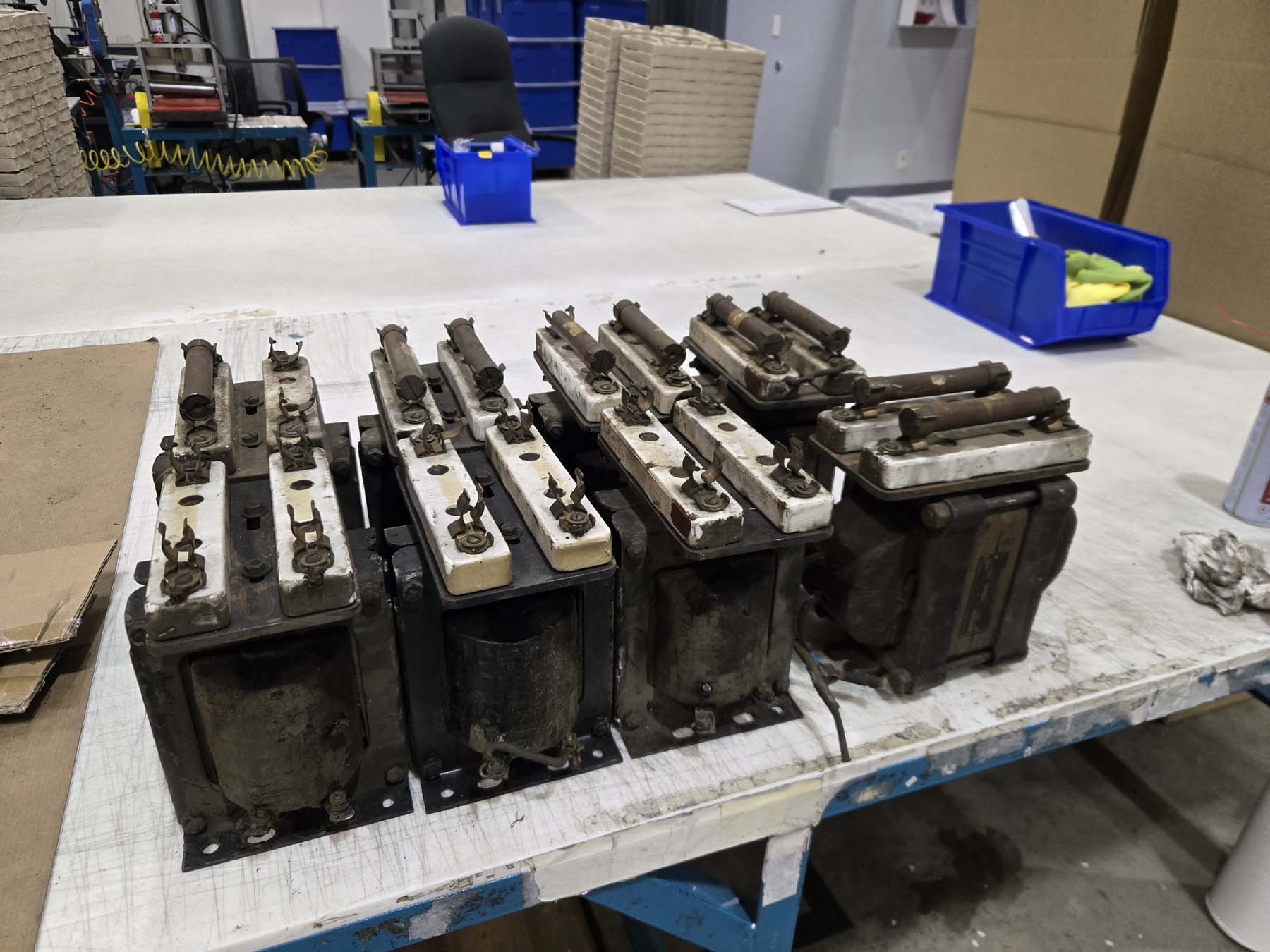
Arresters installed on **Metallic Circuits**, or those not employing a ground return, may use the same ground wire, or the ground wires of a group of Arresters may be run to a common ground.

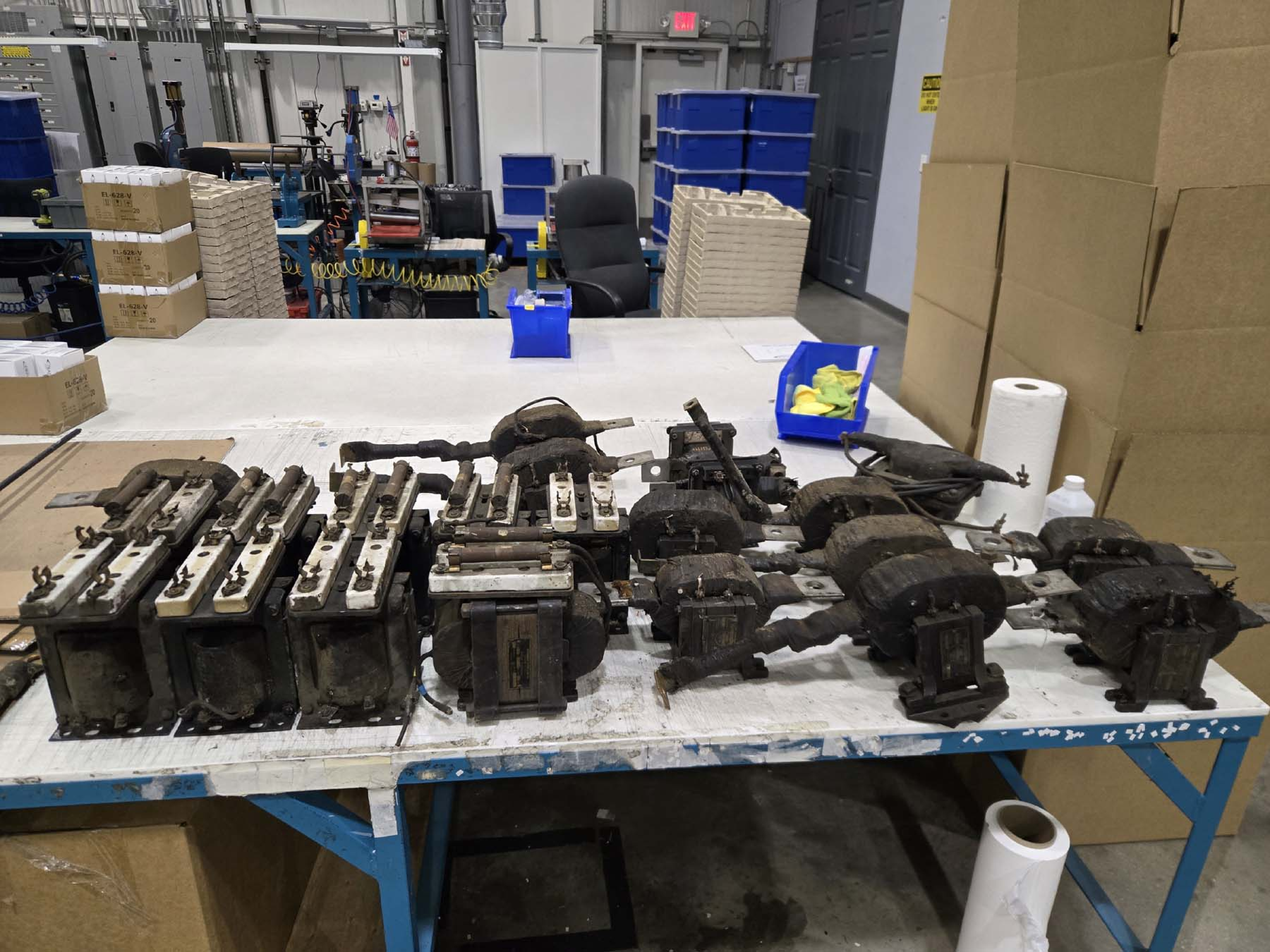
The accompanying cut shows the **Line** and **Ground** connections.

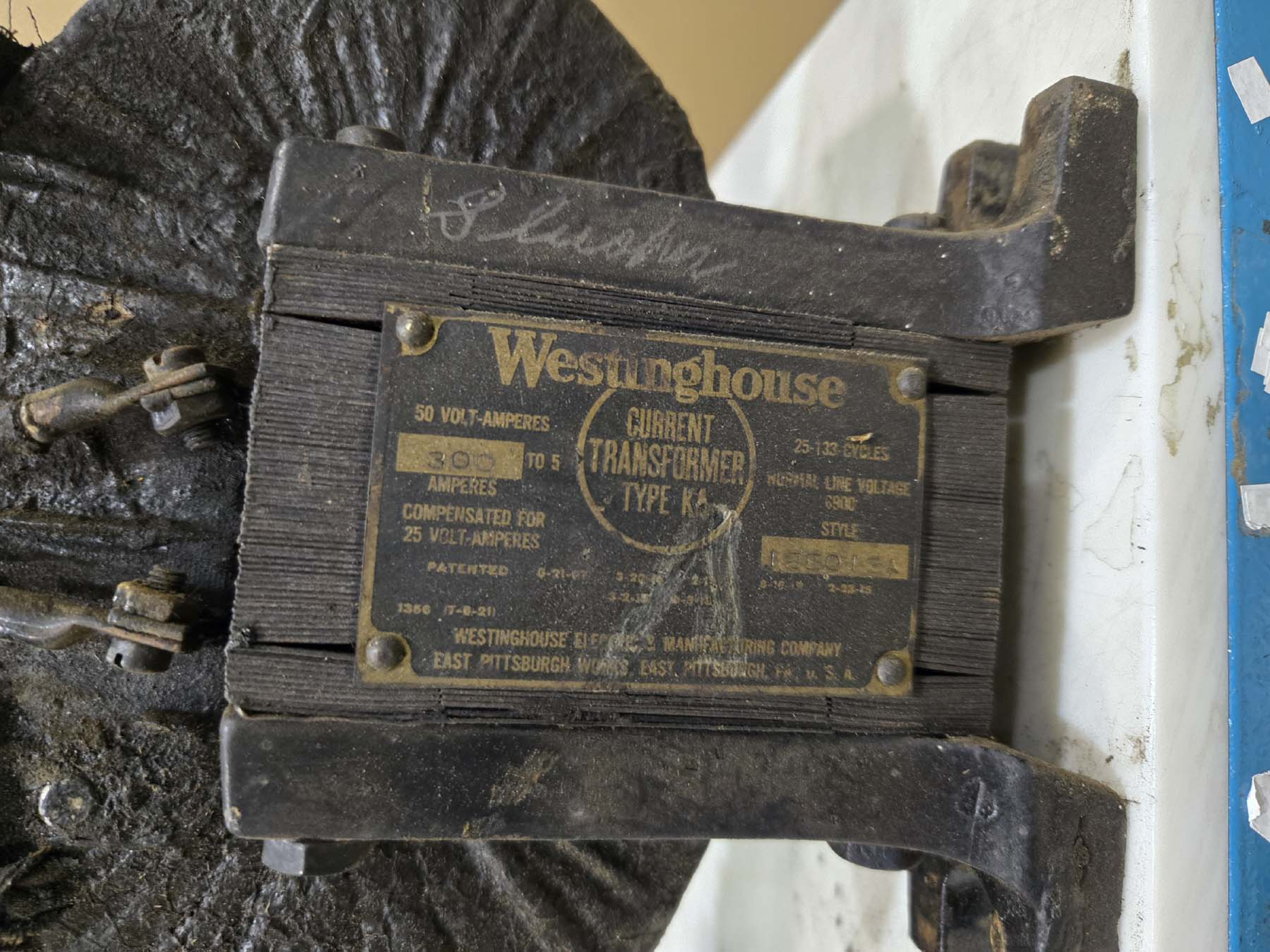
After installing, it is advisable to look at the Arrester occasionally; to see if everything is all right, but beyond this, the Arrester requires no attention, whatever, being purely automatic.

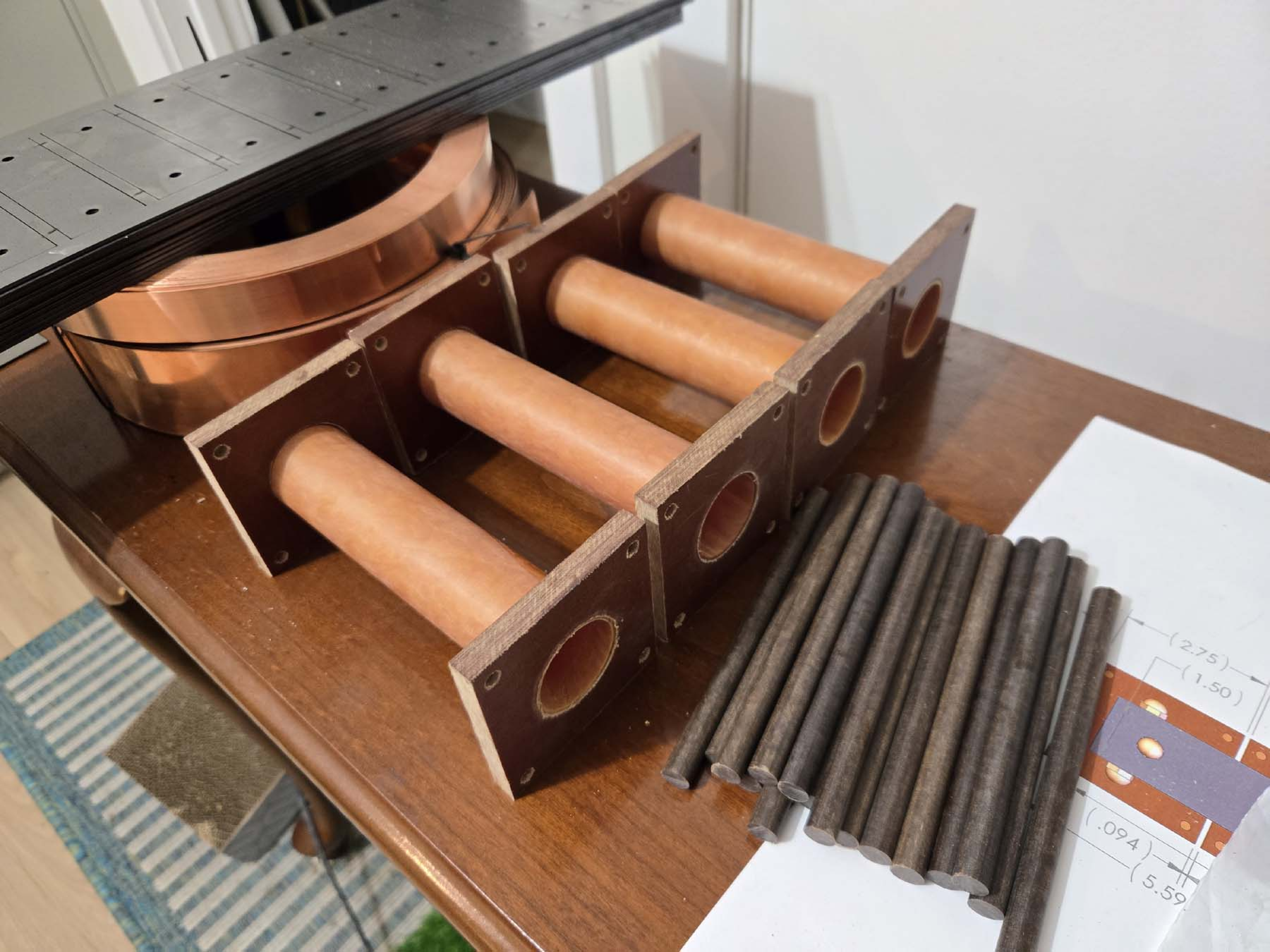
Garton-Daniels Electric Co.

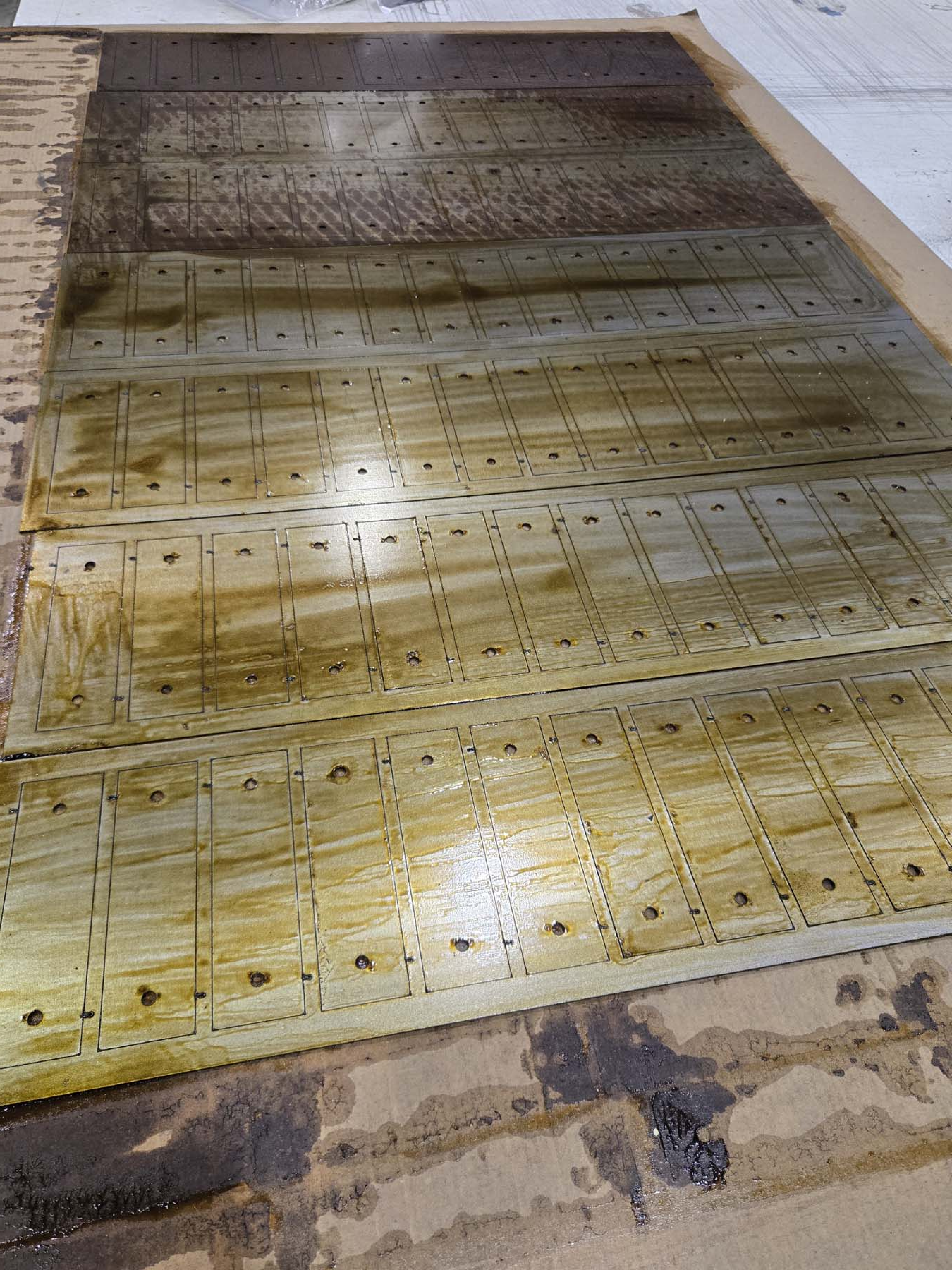
KEOKUK, IOWA, U. S. A.




EXIT
EL-628-V
EL-628-V
EL-628-V
EL-628-V


Westinghouse
50 VOLT-AMPERES
300 TO 5 AMPERES
COMPENSATED FOR 25 VOLT-AMPERES
CURRENT TRANSFORMER TYPE KA
25-133 CYCLES
NORMAL LINE VOLTAGE 6900
STYLE
PATENTED
2-23-15
1366 (7-8-21)
WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY
EAST PITTSBURGH WORKS, EAST PITTSBURGH, PA. U. S. A.

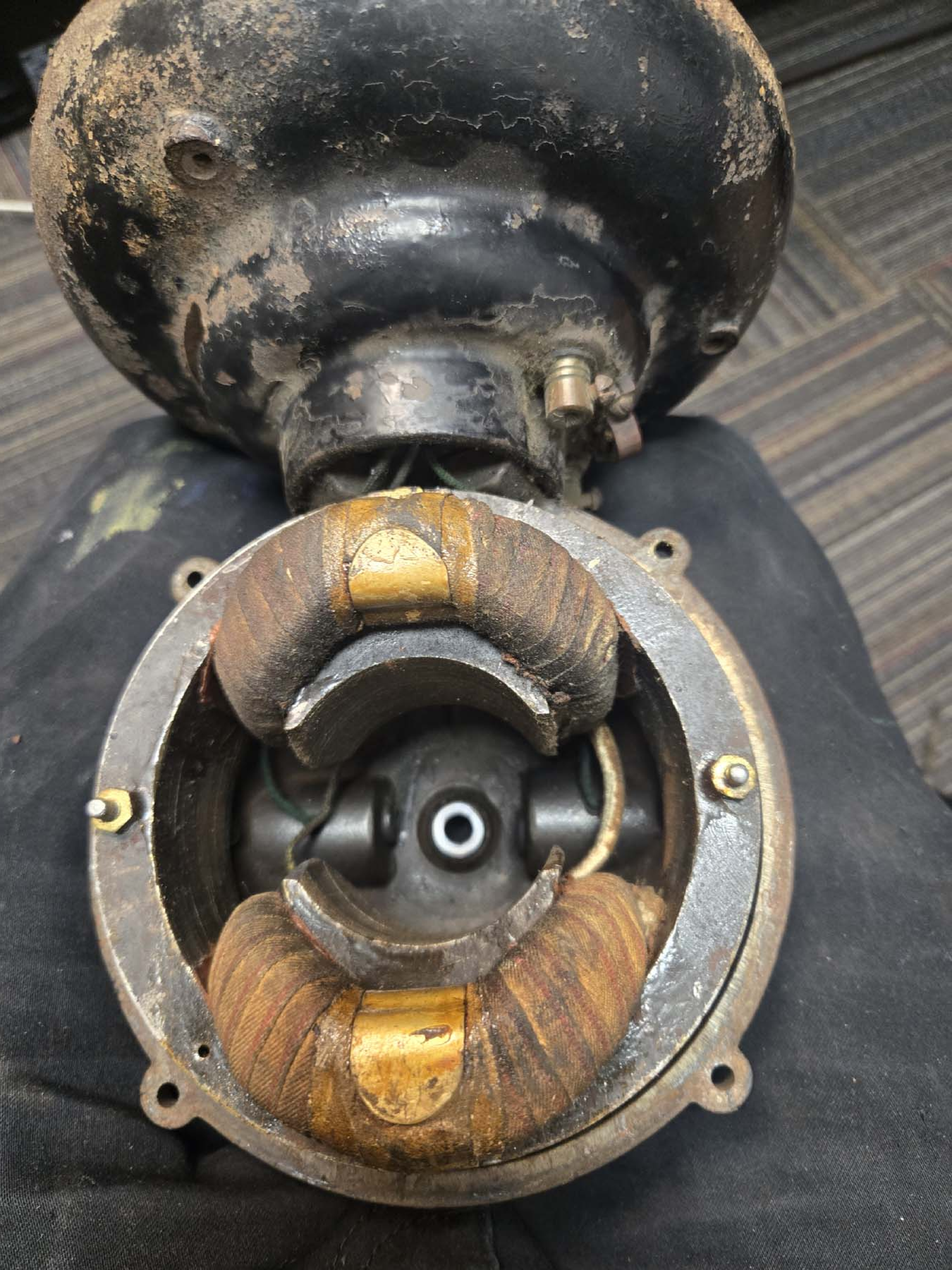

(2.75)
(1.50)
(.094)
(5.59

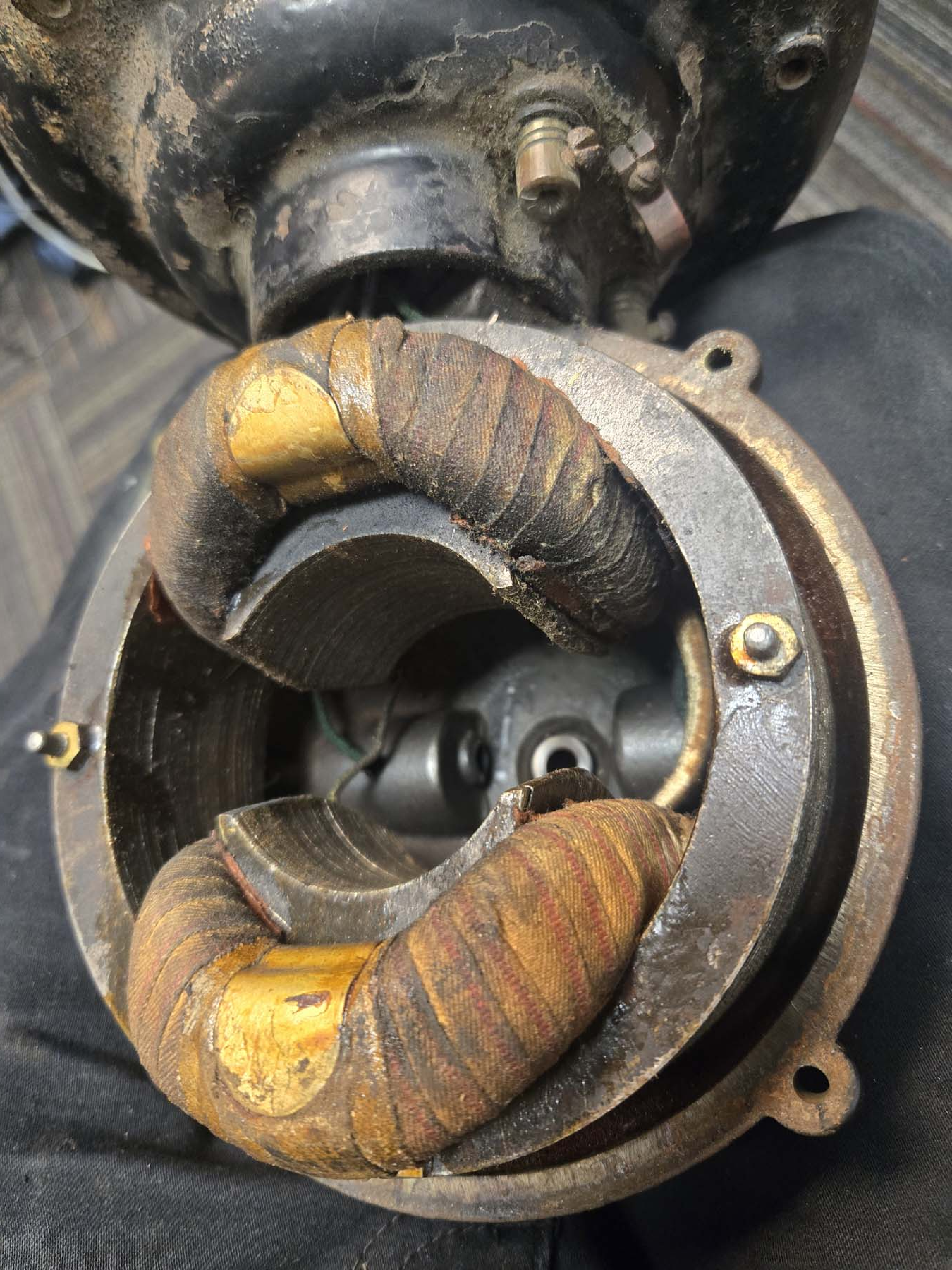


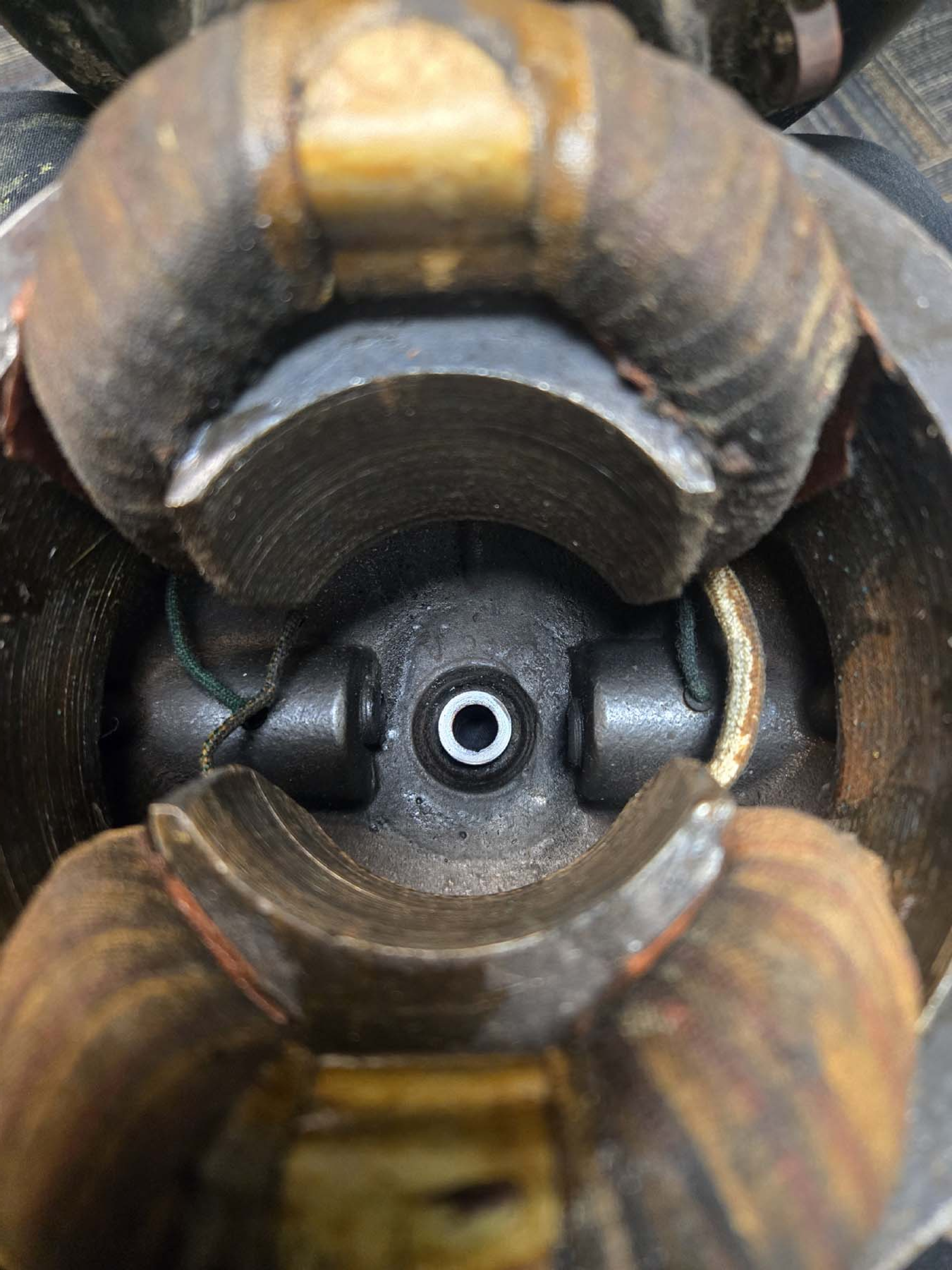
1107
2765
DUNCAN
INTEGRATING WATTMETER
DUNCAN ELECTRIC MFG. CO.
LAFAYETTE, INDIANA, U.S.A.
WESTINGHOUSE ELEC & MFG CO.
EE226
PITTSBURG, PA. U.S.A.
A
SINGLE PHASE
THREE WIRE
WATTMETER
90
EE226 SL
WESTON'S
AMMETER
1107
Westinghouse

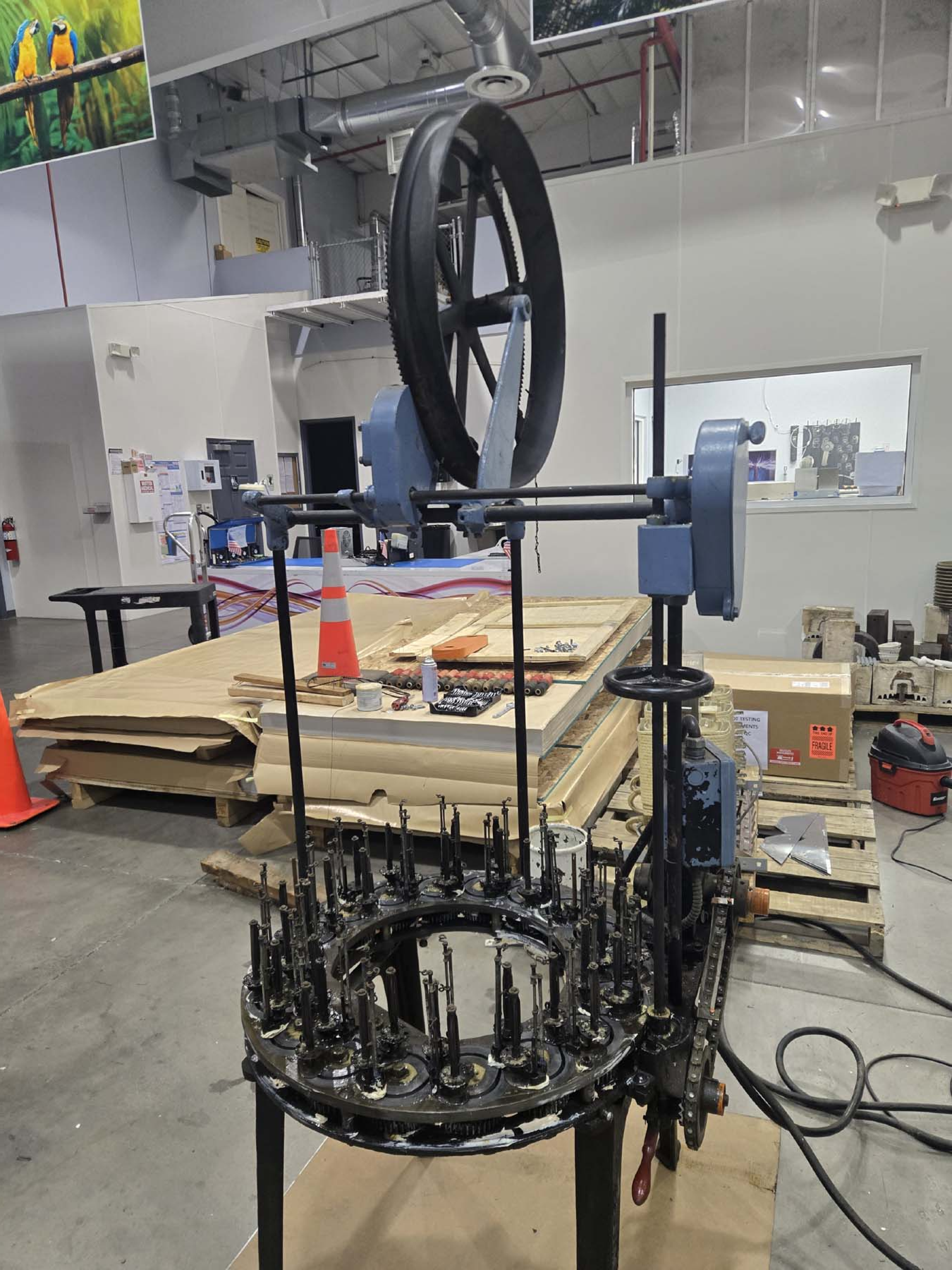
CONDENSER
29
NEW YORK N.Y.
OCTOBER 27 19
TESLA TRANSFORMER
FULL SIZE
TESLA TRANSFORMER
THIS SUMMER IN COLORADO SPRINGS
TESLA
TESLA: a man of the future
1988 INTERNATIONAL TESLA SYMPOSIUM
RED LION INN, COLORADO SPRINGS • JULY 29 - JULY 31
1992 International Tesla Symposium
Sheraton Hotel
Colorado Springs
for information:
COLORADO C
AMPERES
1 Box 8ct
13 88

INTERNATIONAL TESLA SYM
AMPERES
586
KILOWATTS
CYCLES
DEMAND METER
THE LINCOLN METER CO. LIMITED
TORONTO CANADA
Westinghouse





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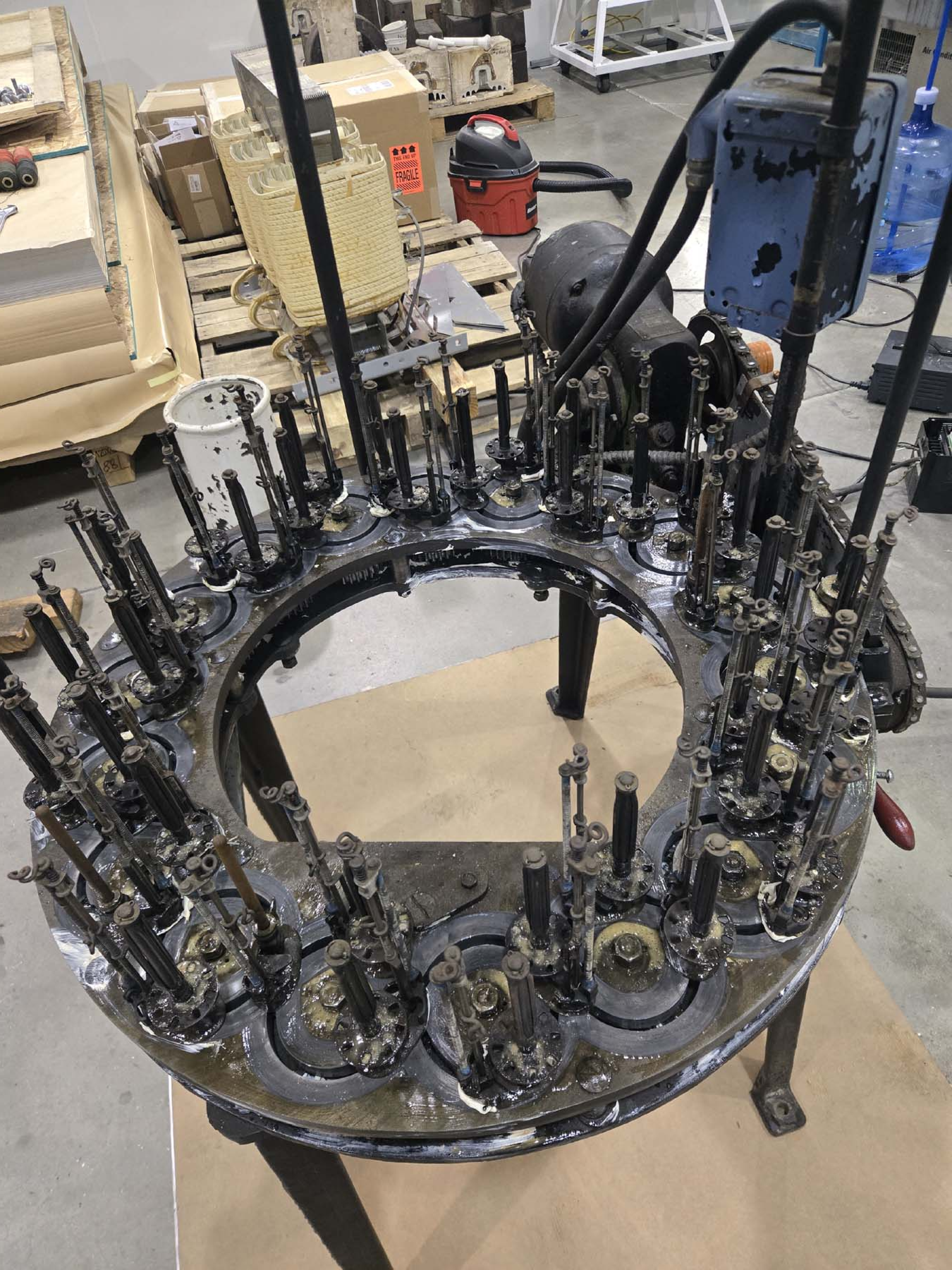
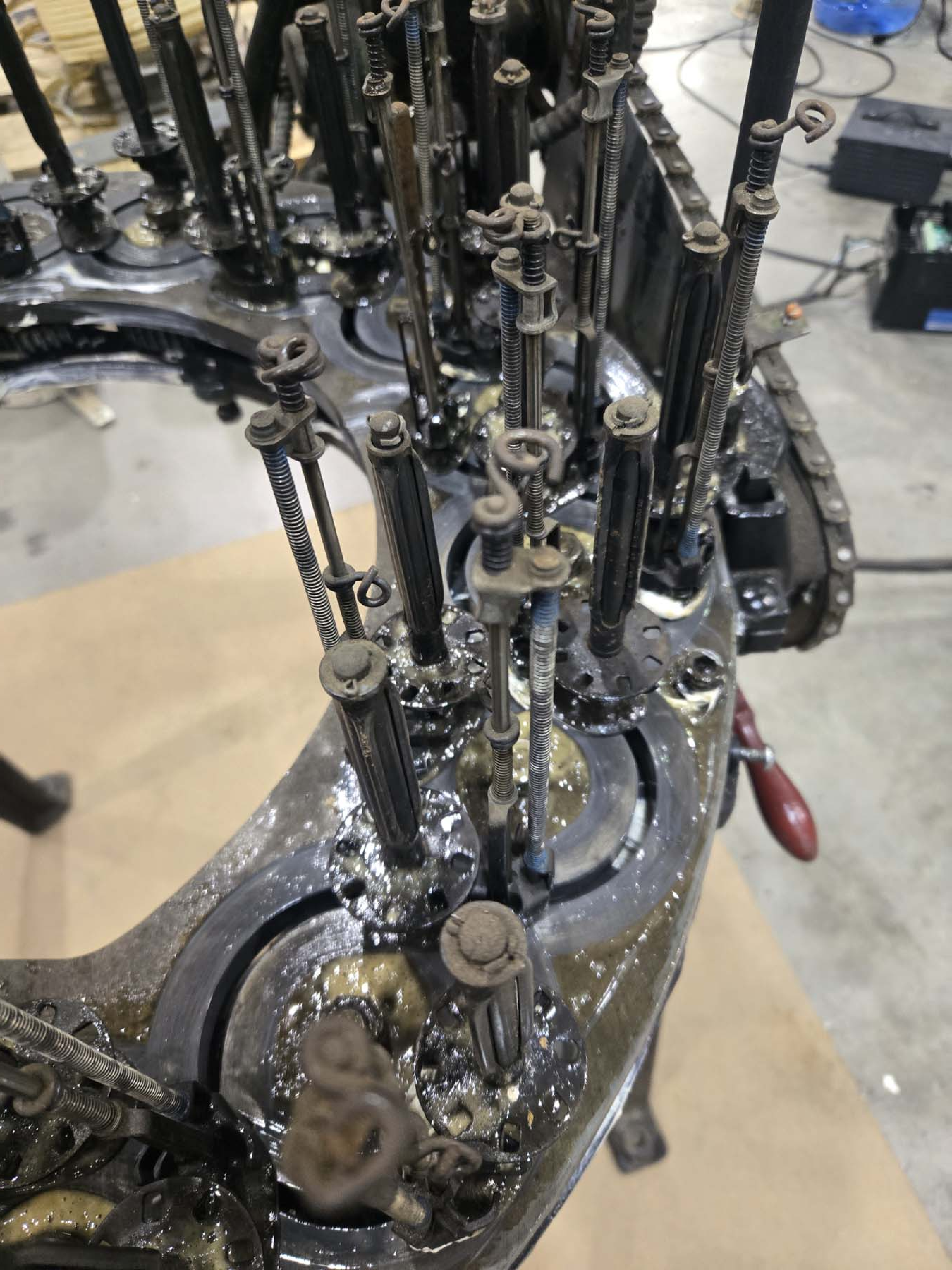
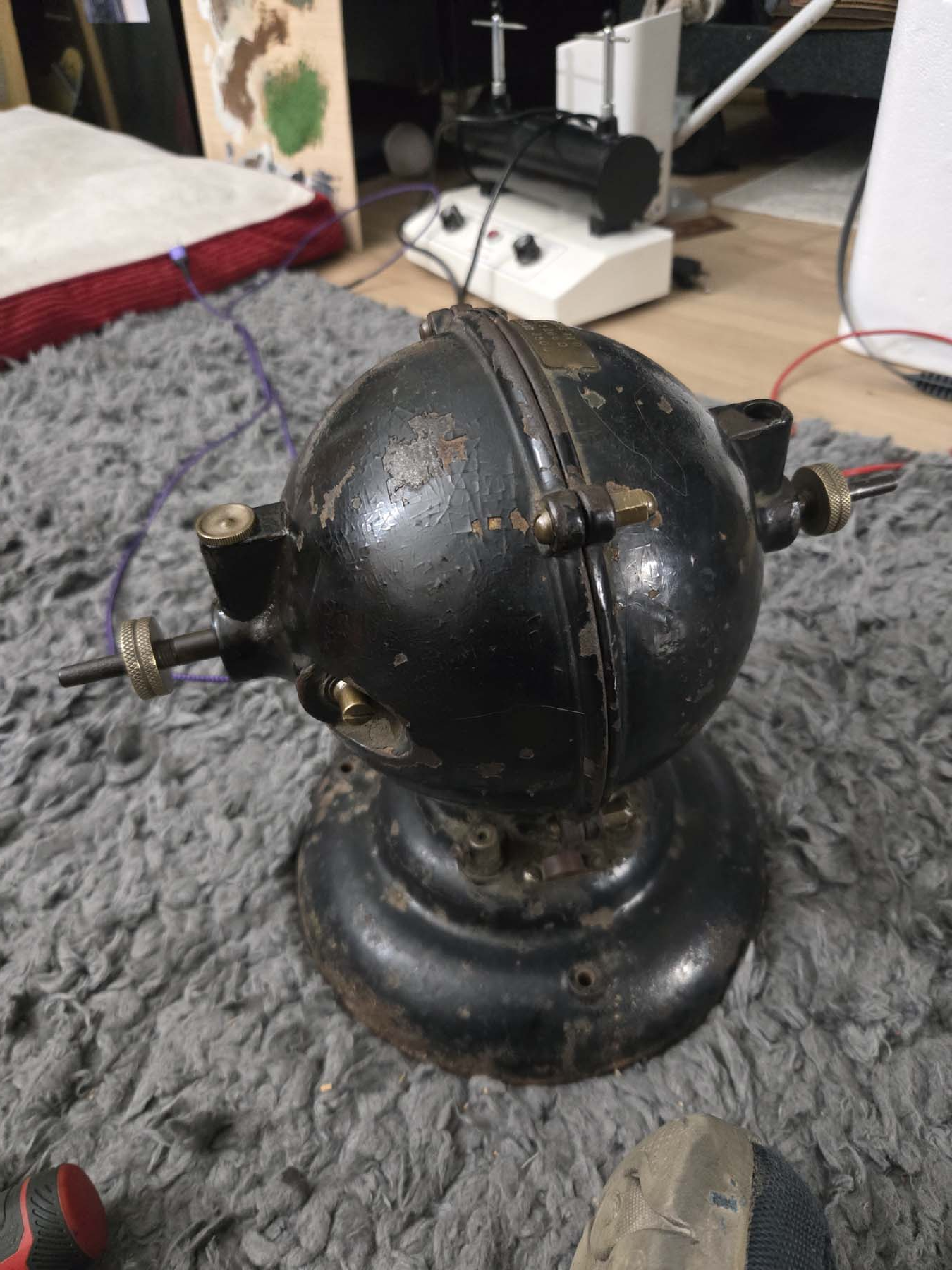
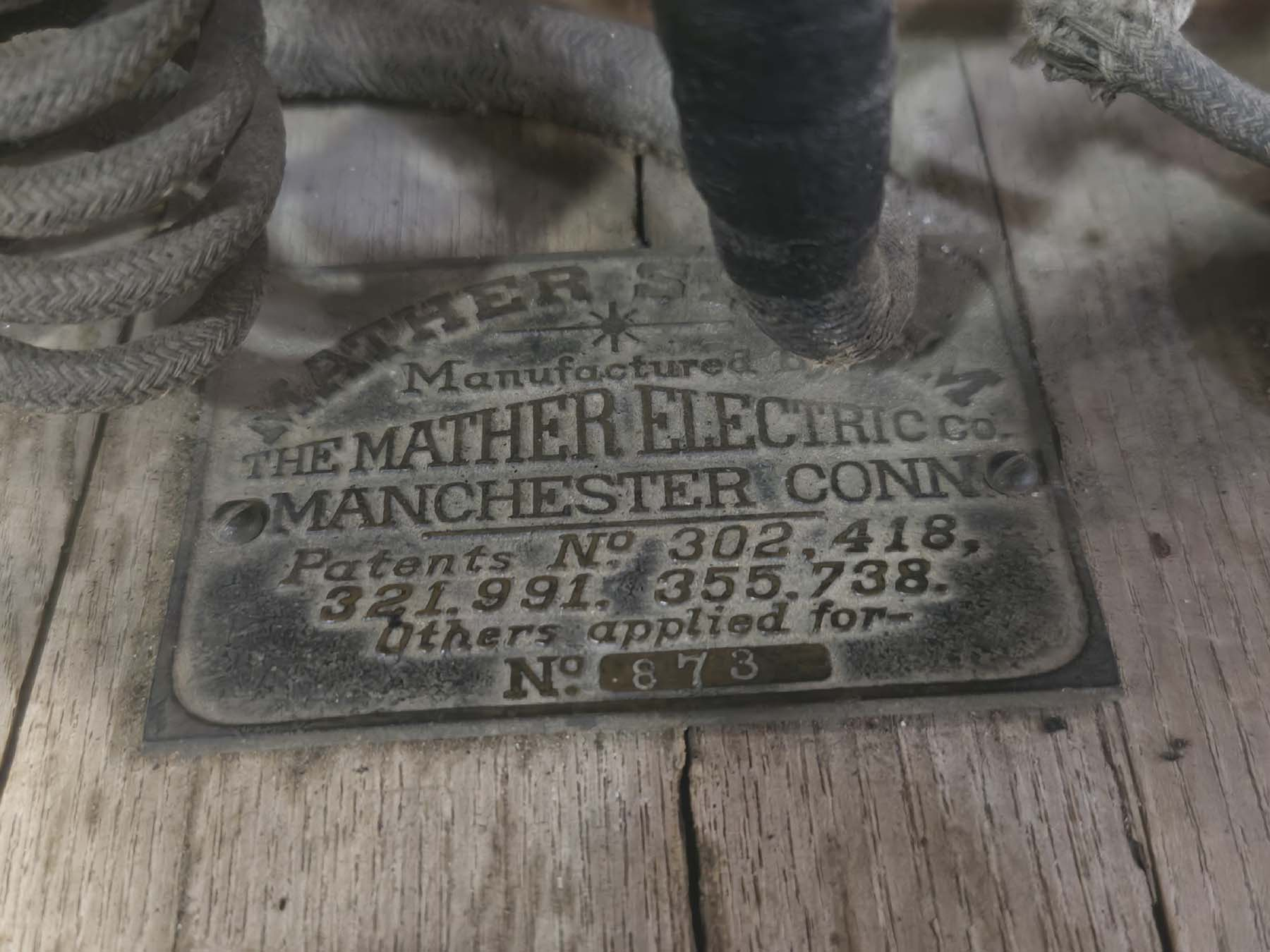

THIS END UP
FRAGILE





LOCKOUT
TAGOUT
STATION



ATHER S M

Manufactured

THE MATHER ELECTRIC Co.

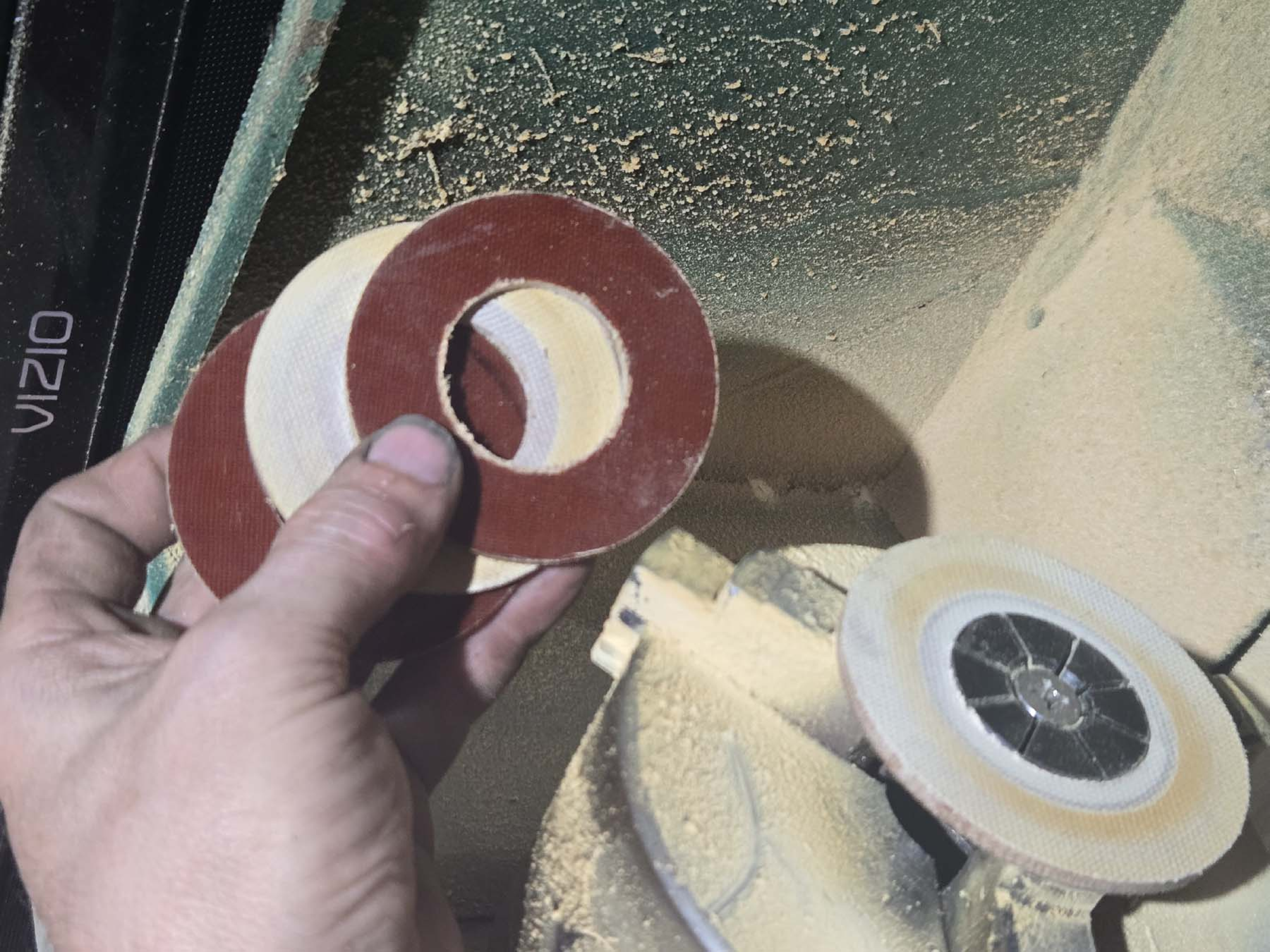
MANCHESTER CONN.

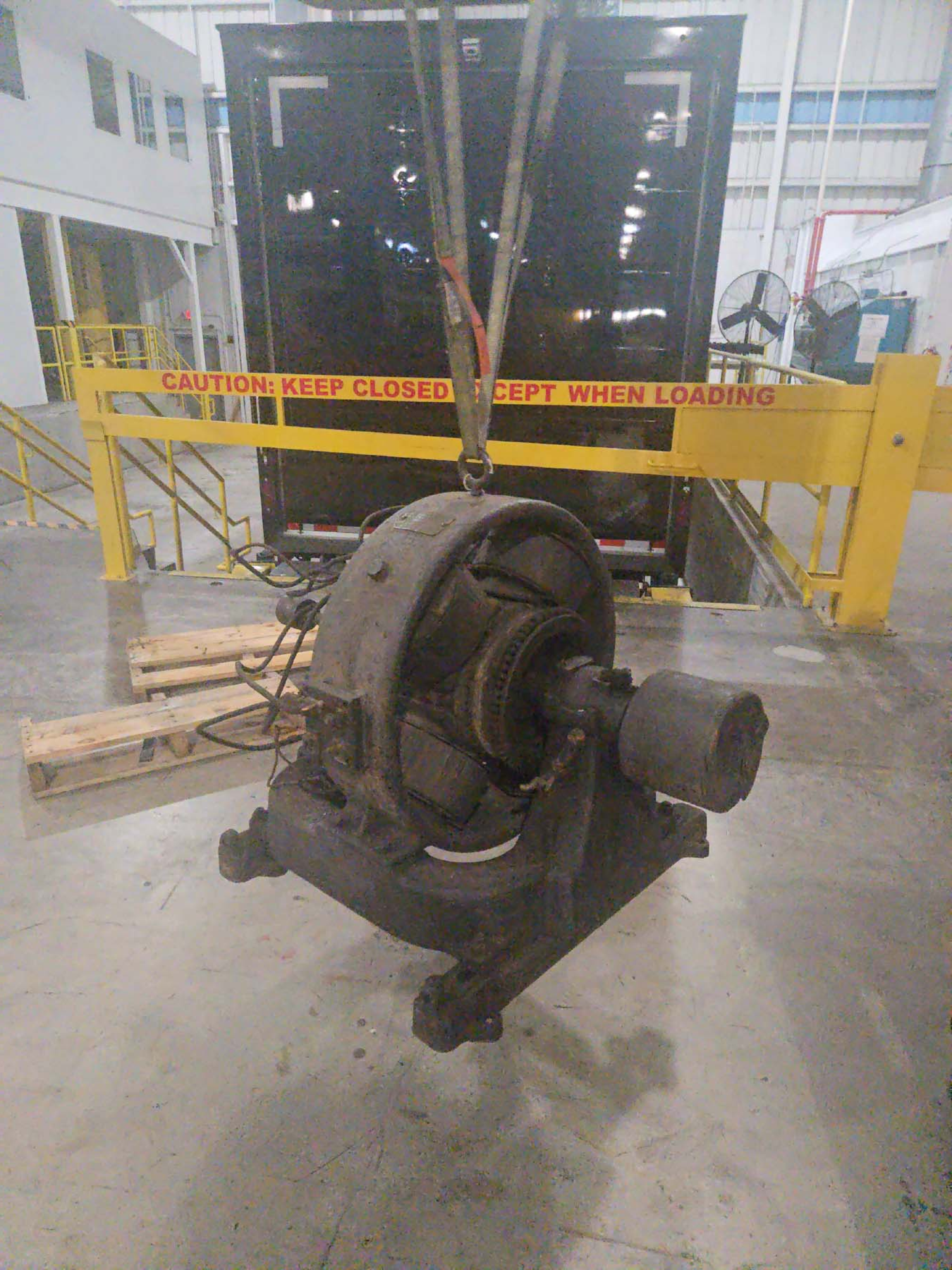
Patents No. 302,418,

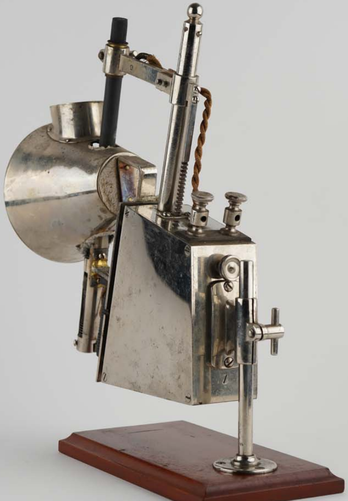
321,991. 355,738.

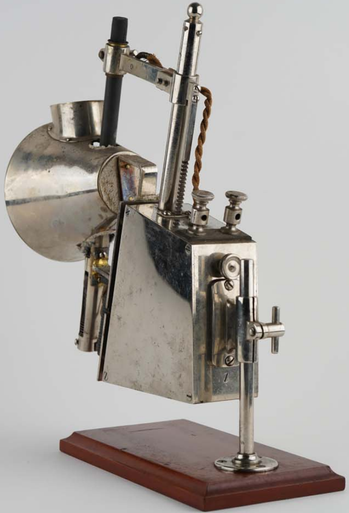
Others applied for-

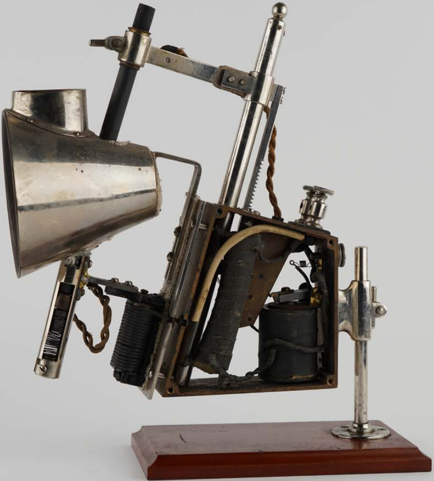
No. 873

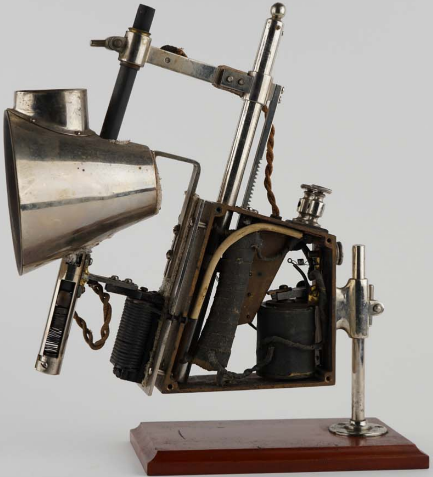

VIZIO

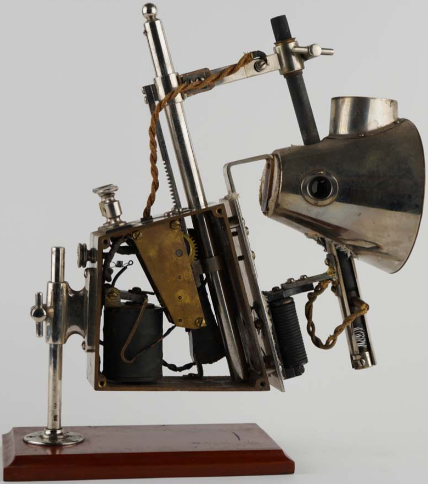

CAUTION: KEEP CLOSED XCEPT WHEN LOADING

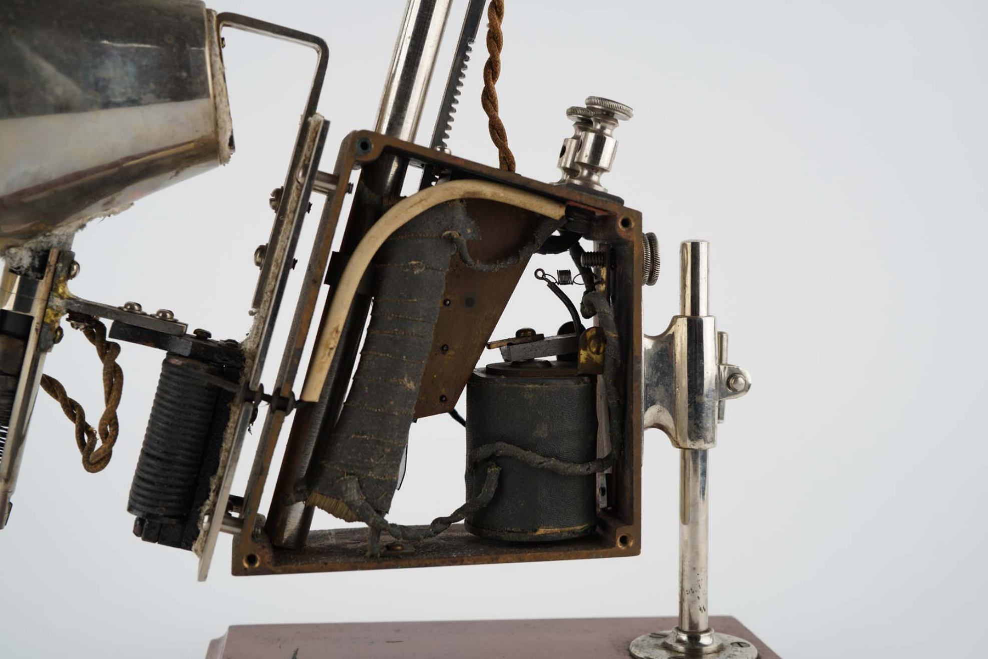


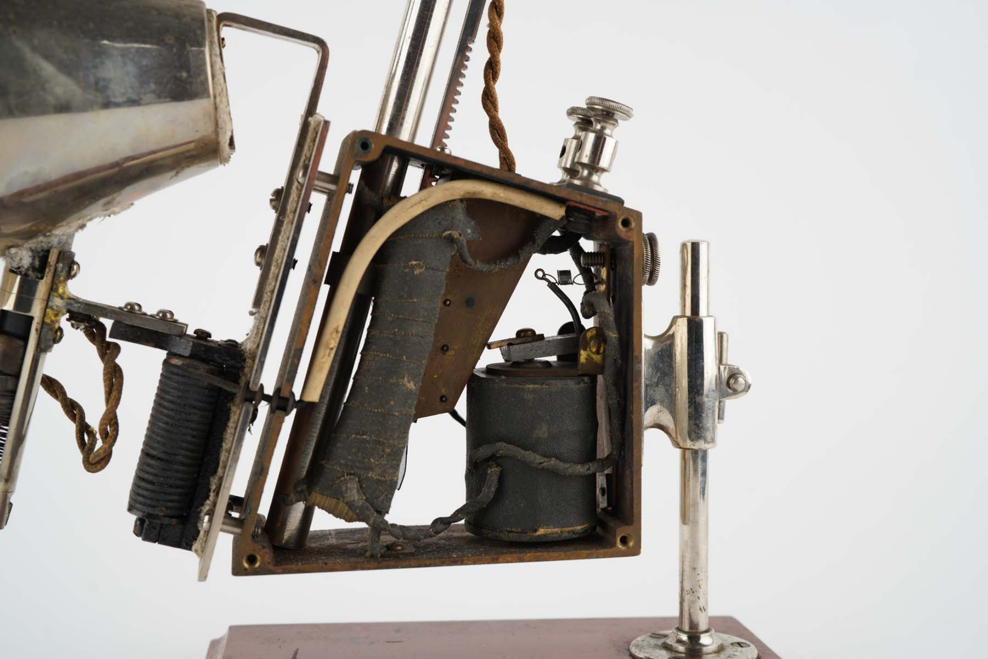


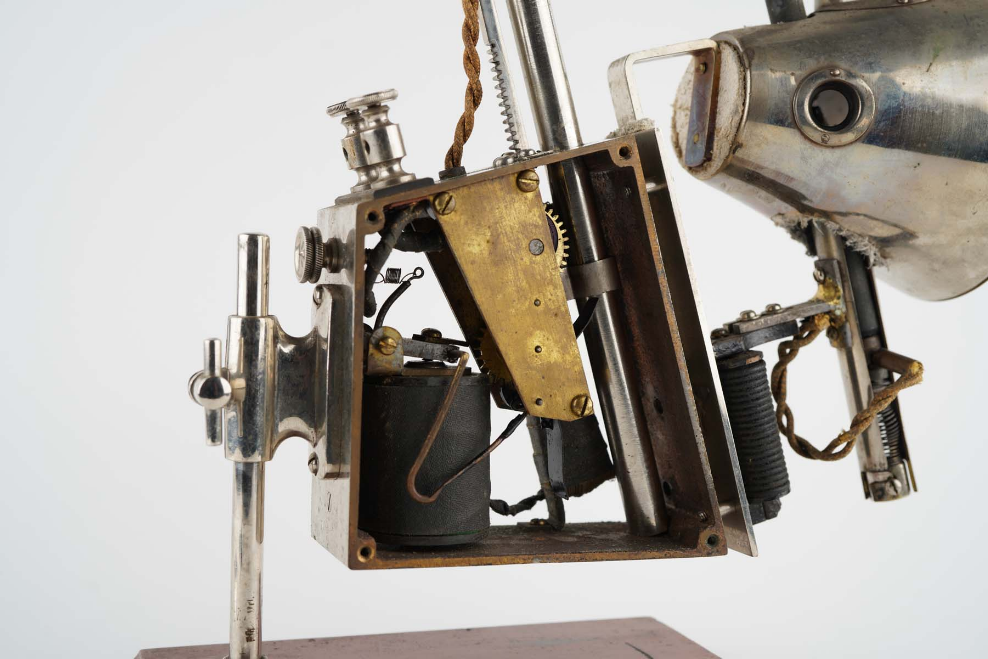


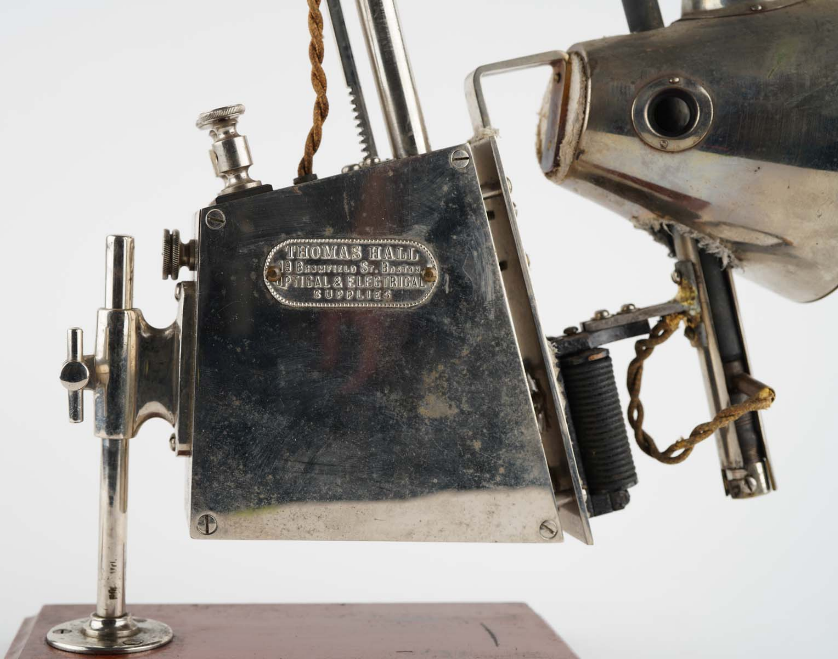


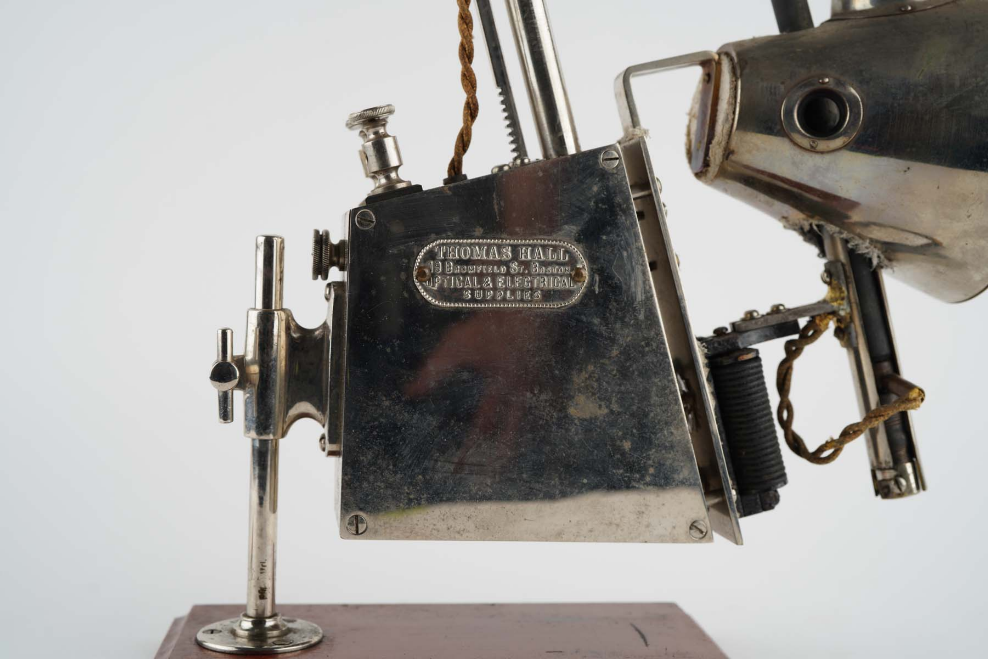


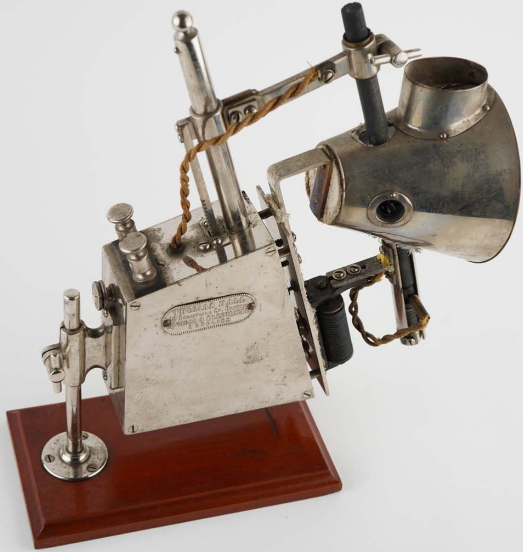


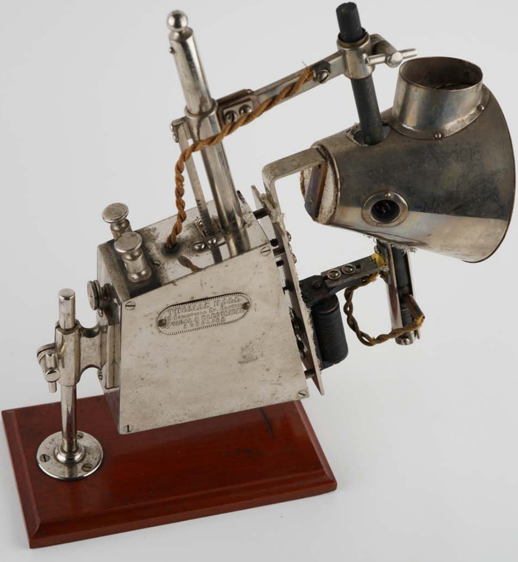


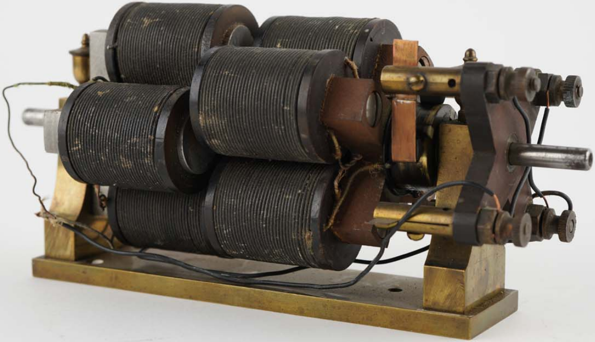


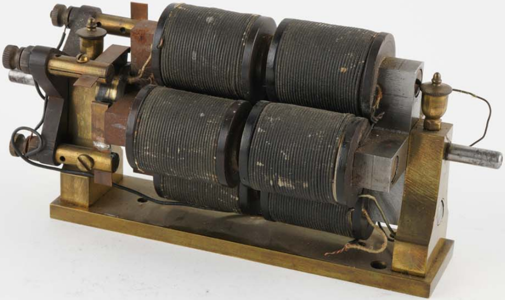

THOMAS HALL
19 BROMFIELD ST. BOSTON.
OPTICAL & ELECTRICAL
SUPPLIES

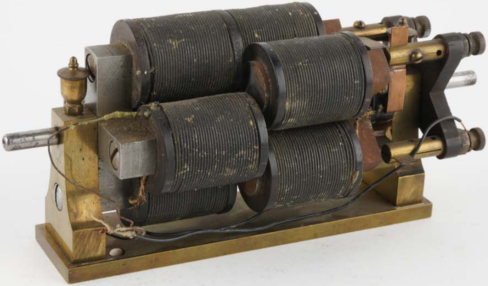

THOMAS HALL
19 BROMFIELD ST. BOSTON.
OPTICAL & ELECTRICAL
SUPPLIES

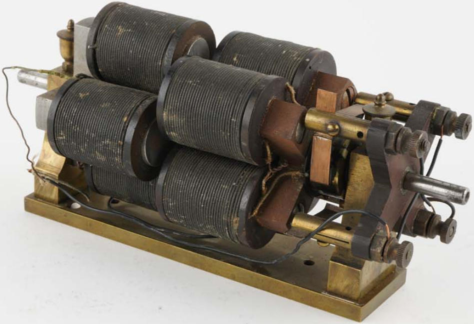

THOMAS HALL

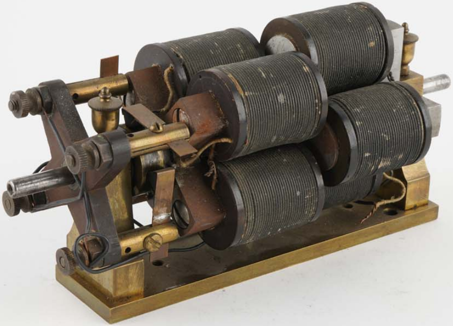

THOMAS HALL

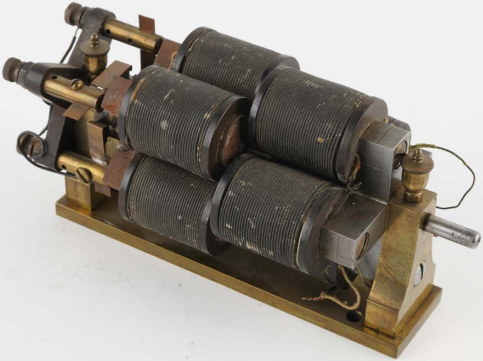


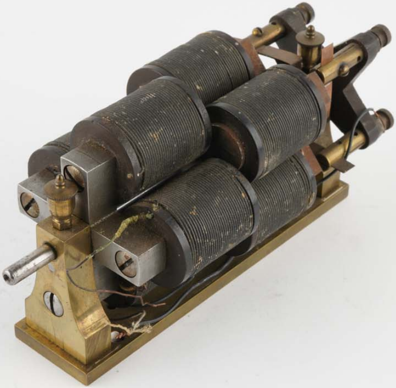


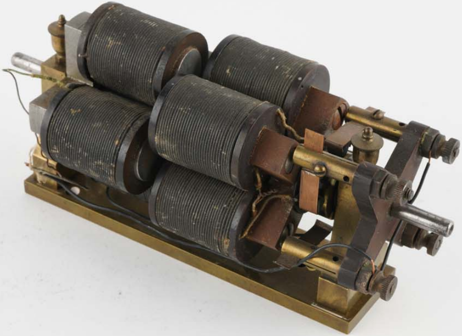


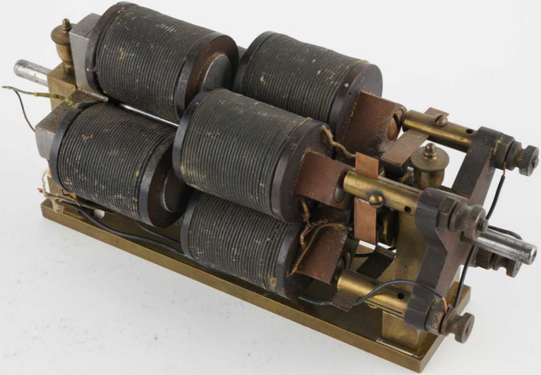


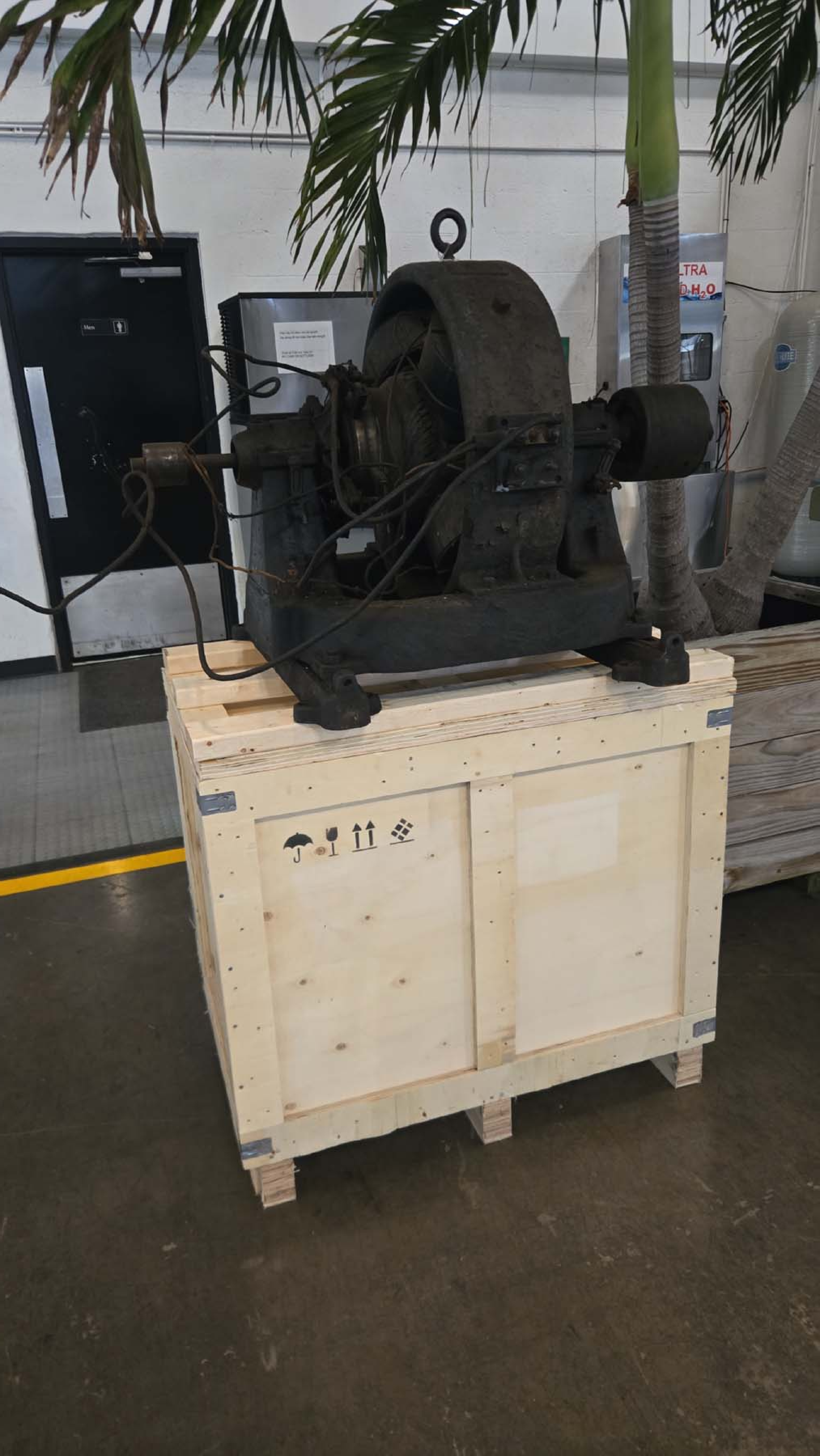


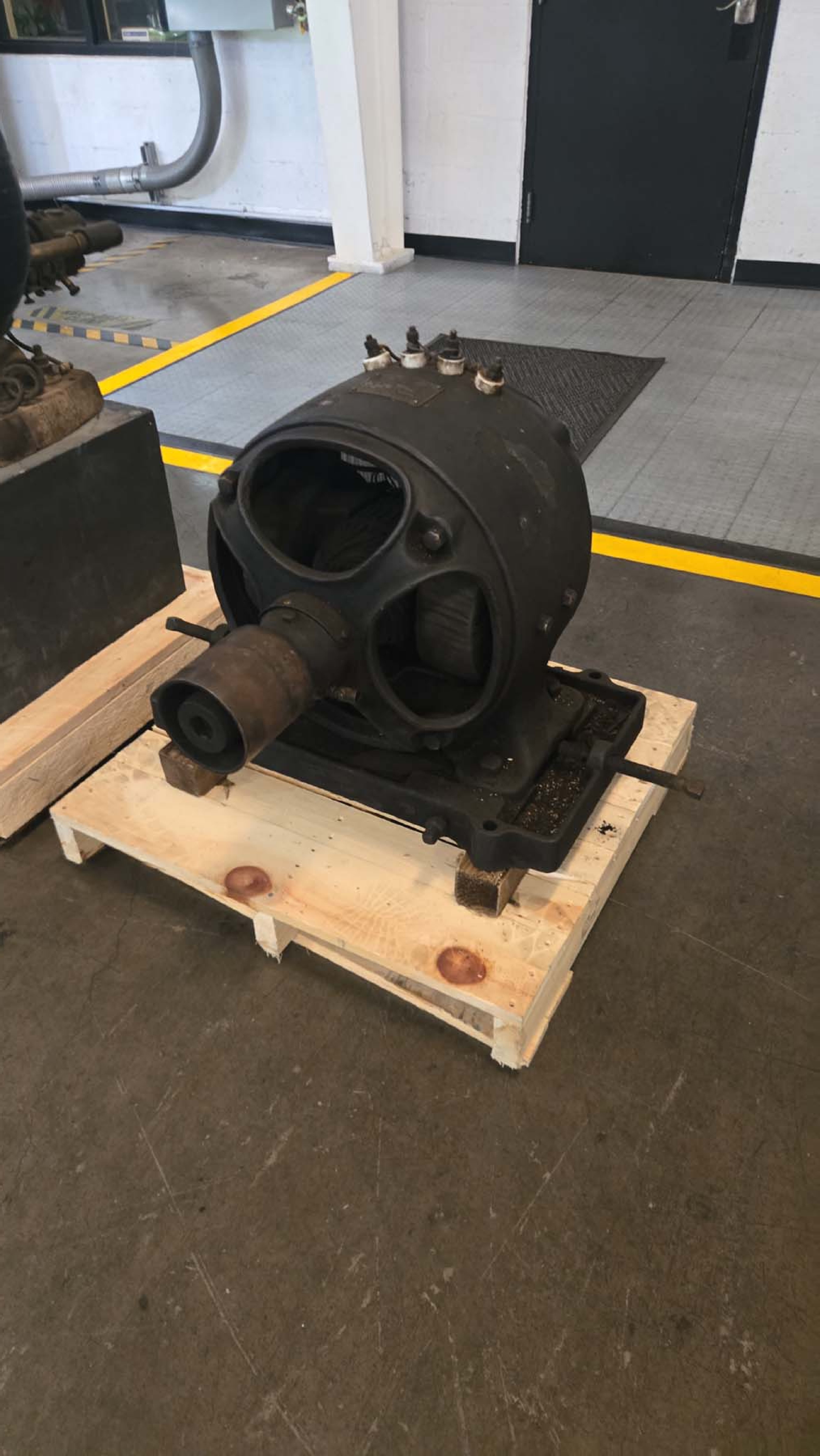


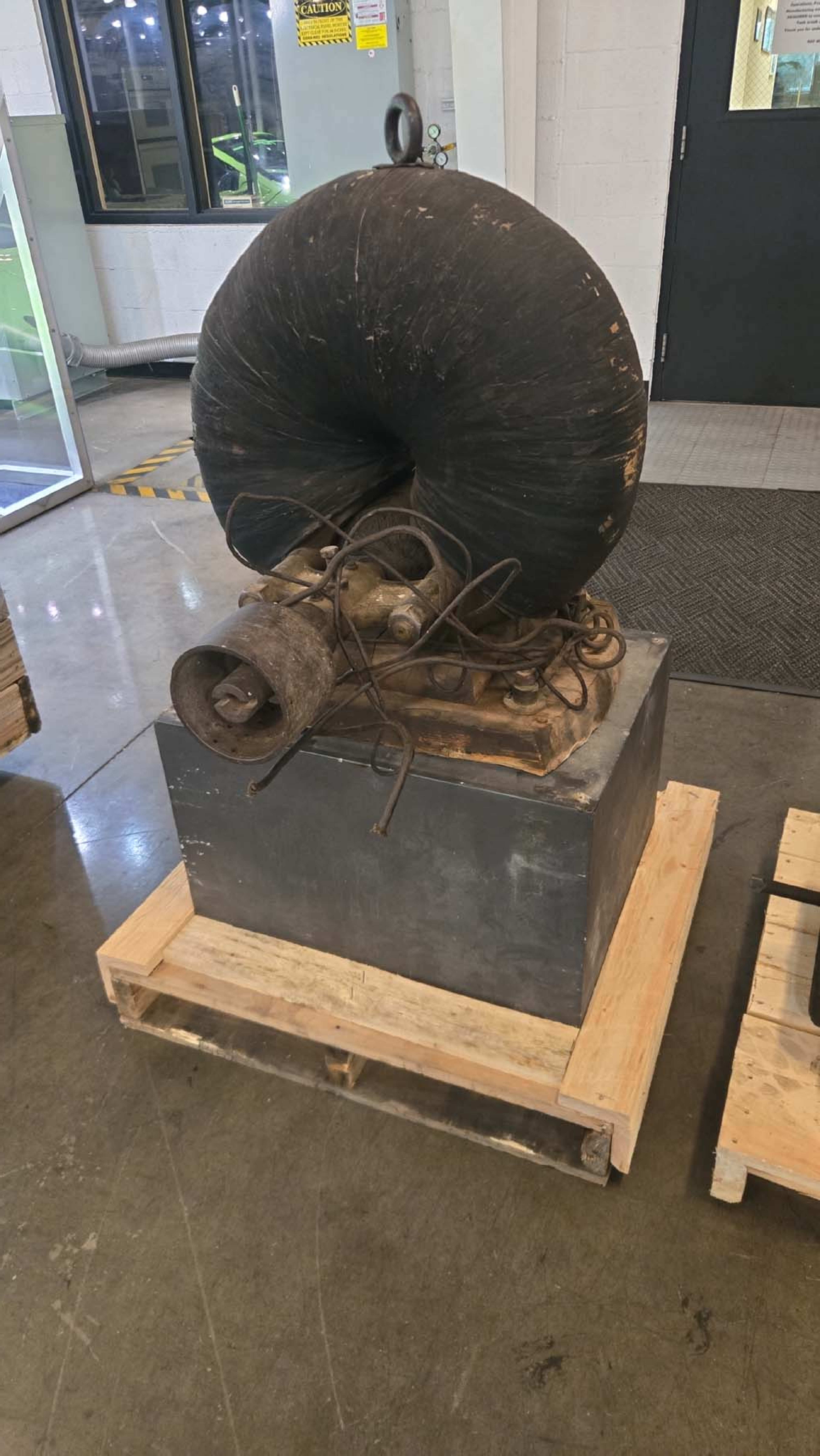


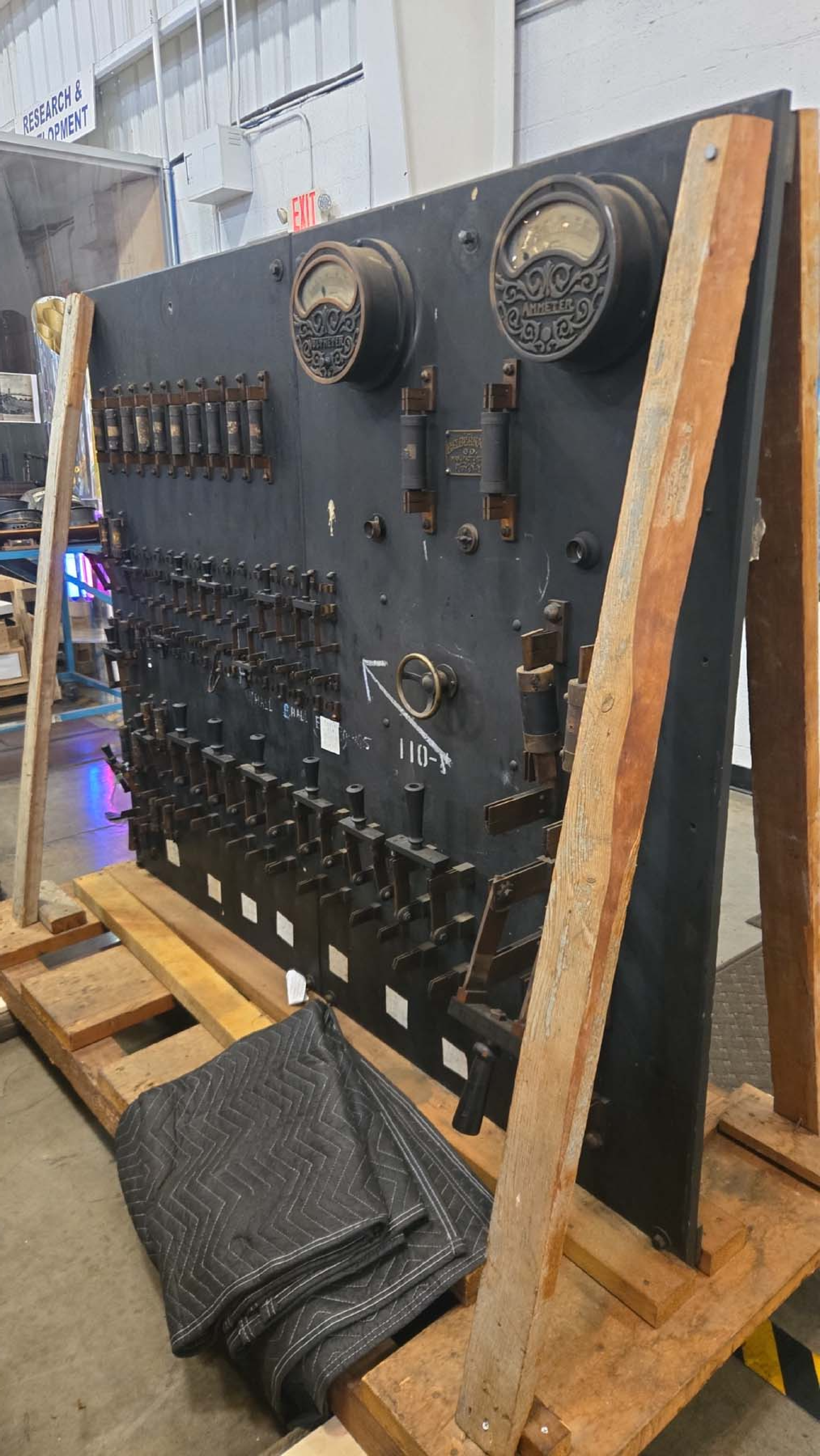




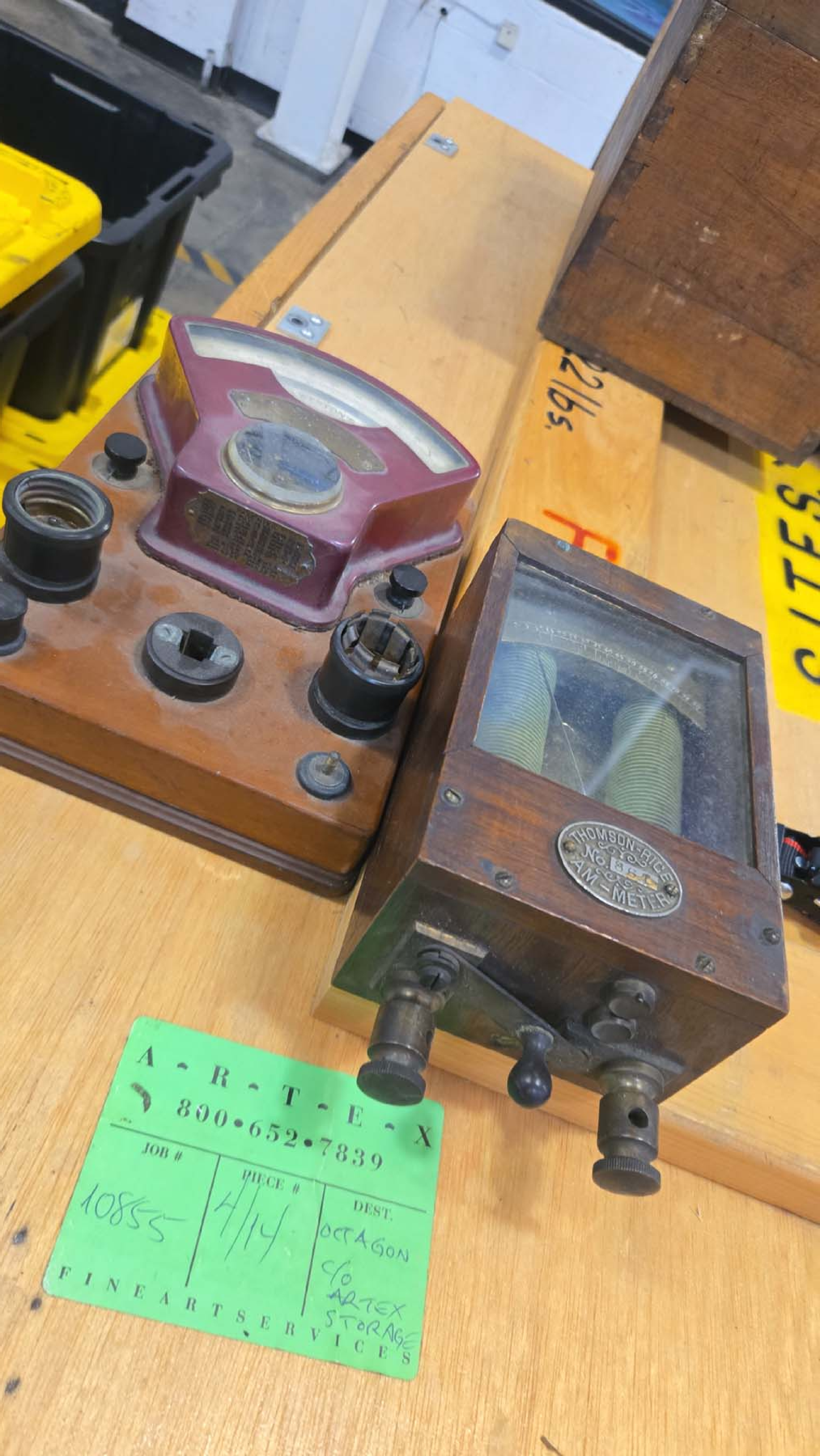

Men

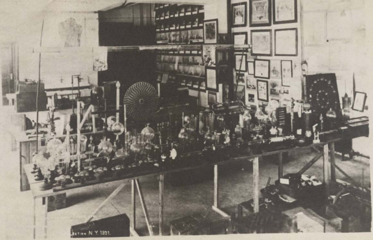



CAUTION


RESEARCH &
ELOPMENT
EXIT
AMMETER
110-

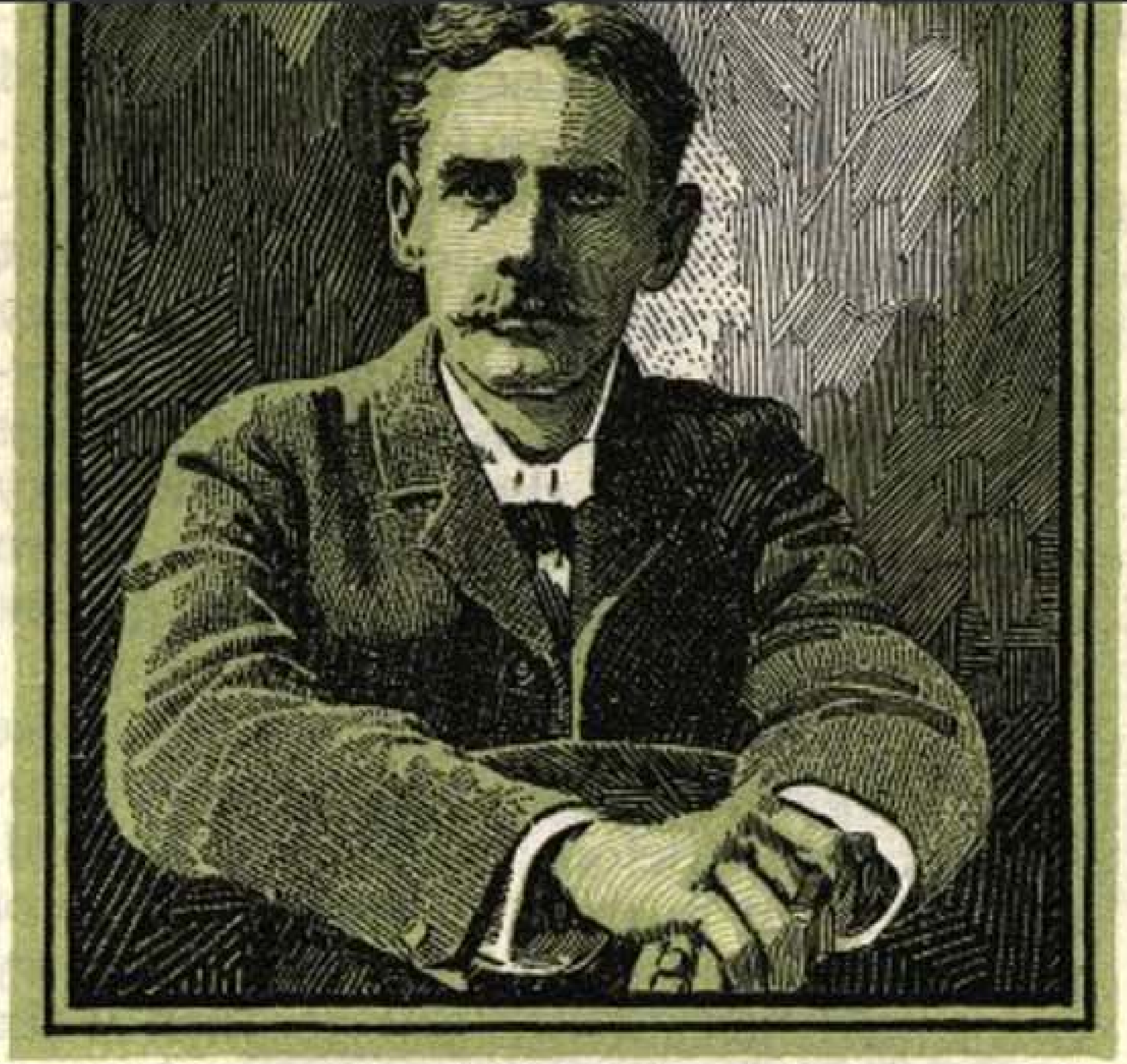
1107
2765
CURRENT AMMETER
1500 2000 2500 300
ELECTRIC COMPANY
PALLET #7
68"x 69"


THOMSON-RICE
No.
AM-METER
62lbs
A·R·T·E·X
800·652·7839
JOB #
10855
PIECE #
4/14
DEST.
OCTAGON c/o ARTEX STORAGE
FINE ART SERVICES


ECTION N.Y. 1931.

TUBES.

(Old picture - as formerly displayed)



WILLIAM STANLEY

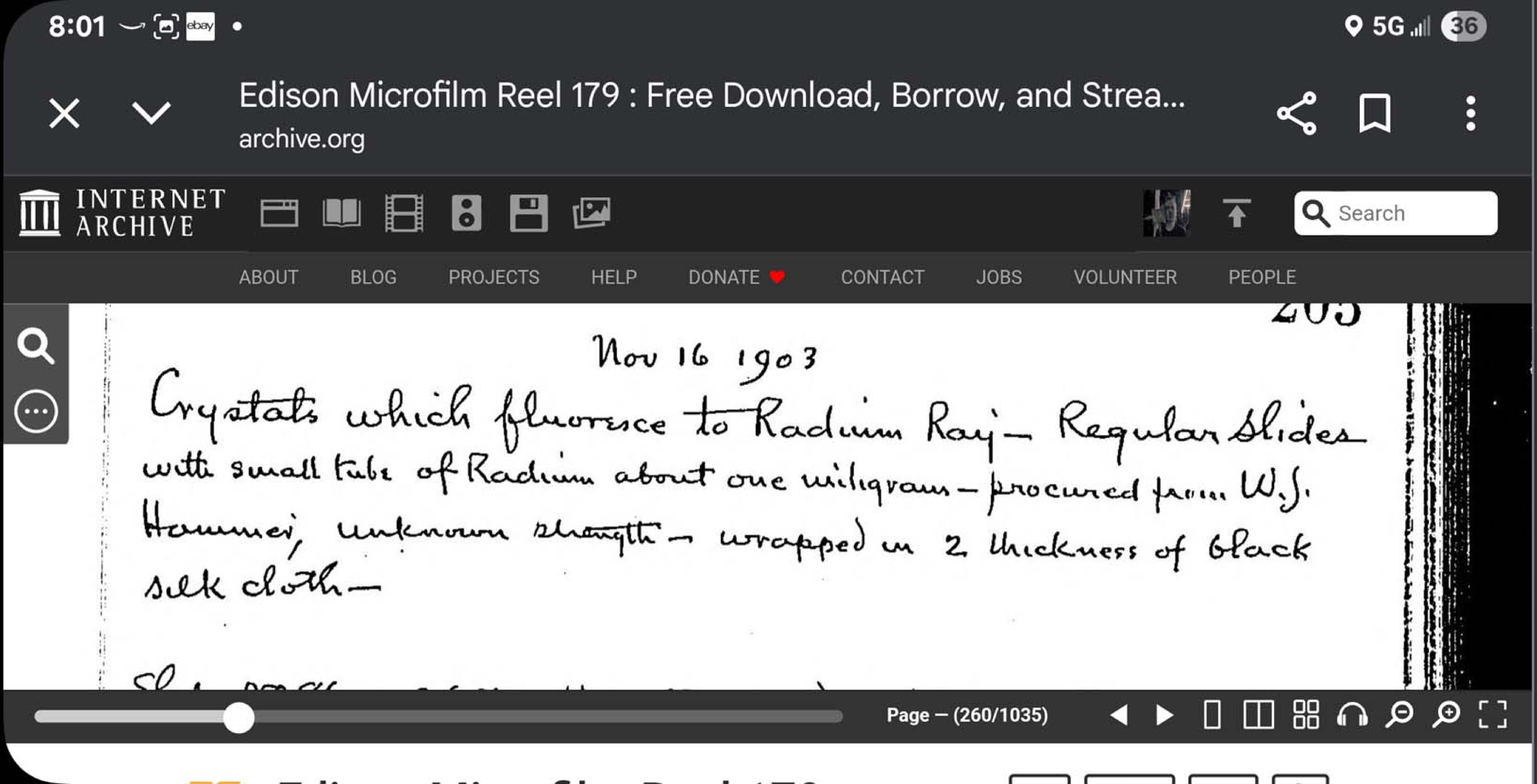
Just previous to his connection with the electrical industry, Mr. Westinghouse had developed a system for the distribution of gas to consumers. In this arrangement the gas was conducted over long distances under high pressure and the pressure then reduced for general use.

electricity must follow this same principle. When the Gaulard and Gibbs transformer was brought to his attention he immediately recognized this device as his "pressure reducer" and acquired the patent rights. When the devices were tested, it was recognized that they required much development and to Mr. Stanley was assigned the task of developing the transformer and the system. This experimental work was conducted by Mr. Stanley at Great Barrington, Mass. He made important improvements in the design of the transformer itself and arranged to connect them in parallel, thus laying the foundations of the present alternating current system.

Commercial generators and transformers with the necessary auxiliary apparatus were then developed at Pittsburgh and the alternating current system was rapidly adopted and its use widely extended.

Two important things were now needed to make the new system of universal service and Mr. Westinghouse at once busied himself to obtain them.

First, there was no meter in existence to measure the alternating current and second


8:01
5G 36
Edison Microfilm Reel 179 : Free Download, Borrow, and Strea...
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PEOPLE
Page — (260/1035)

Nov 16 1903

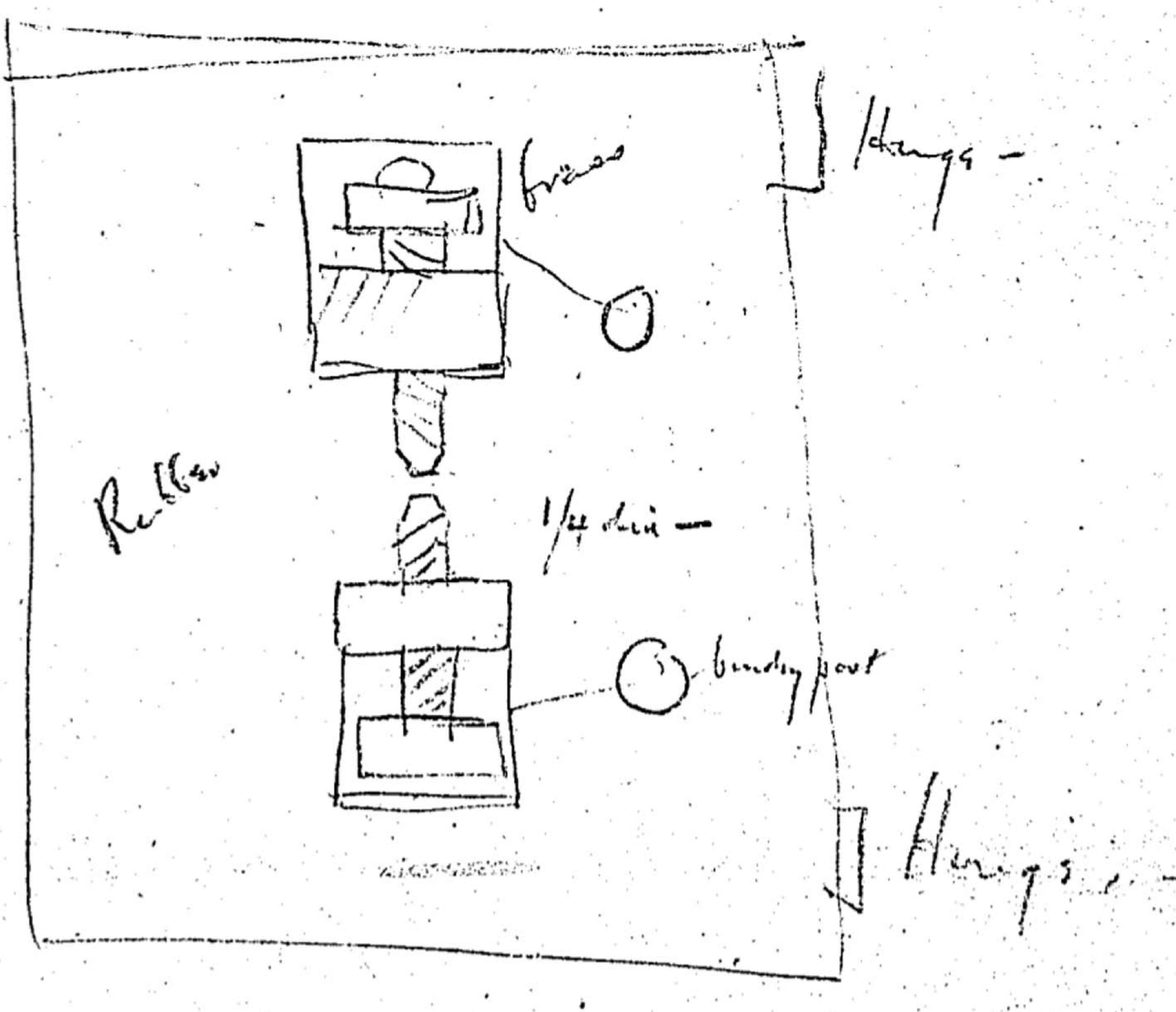
Crystals which fluoresce to Radium Ray— Regular Slides with small tube of Radium about one miligram — procured from W.J. Hammer, unknown strength — wrapped in 2 thickness of black silk cloth—

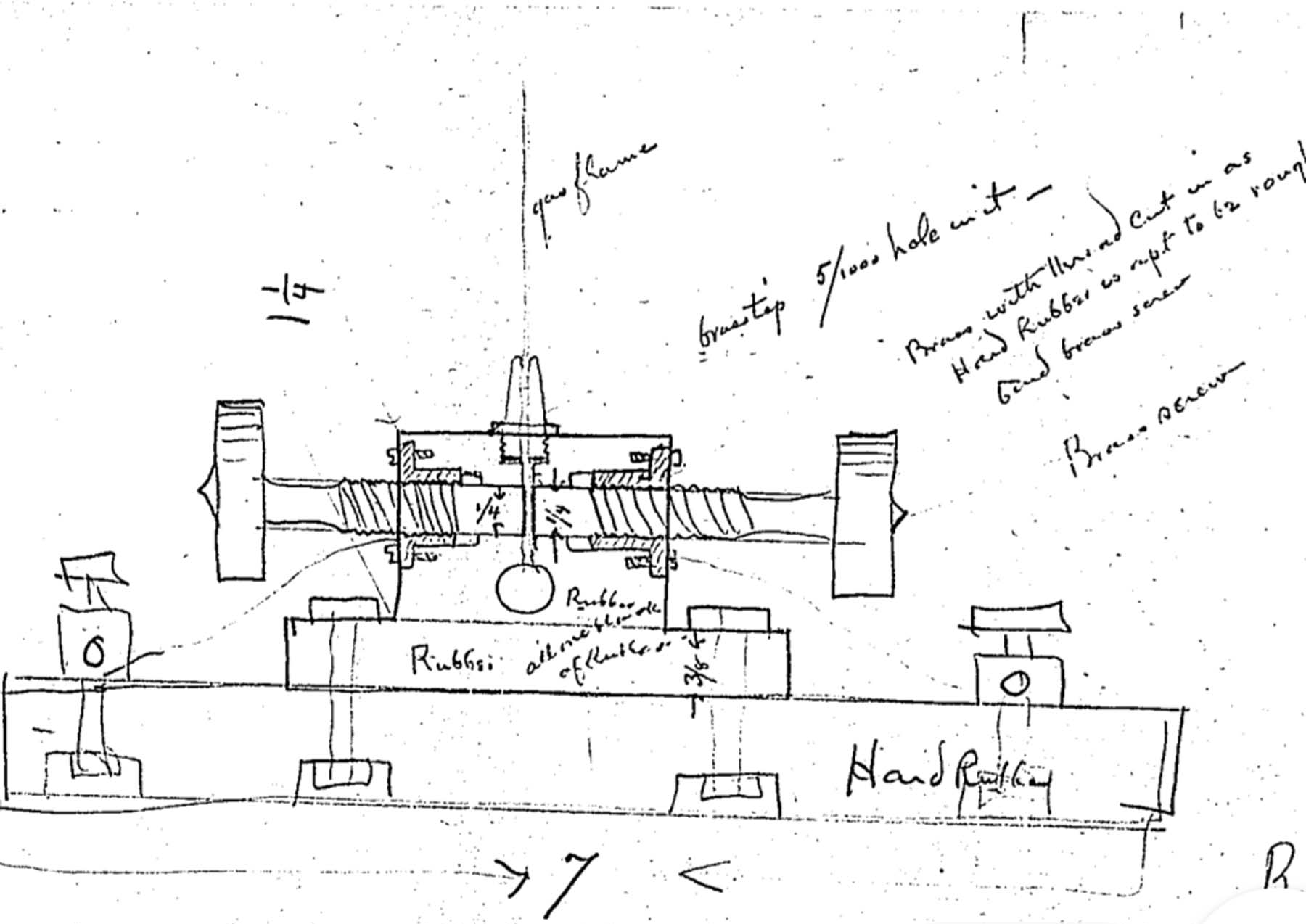
9:44
5G+
36
edisonmicrofil...

This wants to be well made as there will be several hundred slides to go in & out, & it must be Easy & quick to change them —

The Carpenter is to make 300 slides of which 50 slides are to be put in a box, This will make 6 boxes these boxes should have cleats so Each slide when put in box goes in Easy & dont touch the other slides. The box should have a Cover ~~[illegible]~~ & handle —

There are I think 40 or 50 places on Each slide for Crystals


Brass
Hinge —
Rubber
1/4 dia —
binding post
Hinge —


gas flame
-1/4
brass tip 5/1000 hole in it —
Brass with thread cut in as
Hard Rubber is apt to be roug
Good brass screw
Brass screw
1/4
1/4
Rubber or all metal
Rubber all metal of Rubber
3/8
Hard Rubber
> 7 <
R

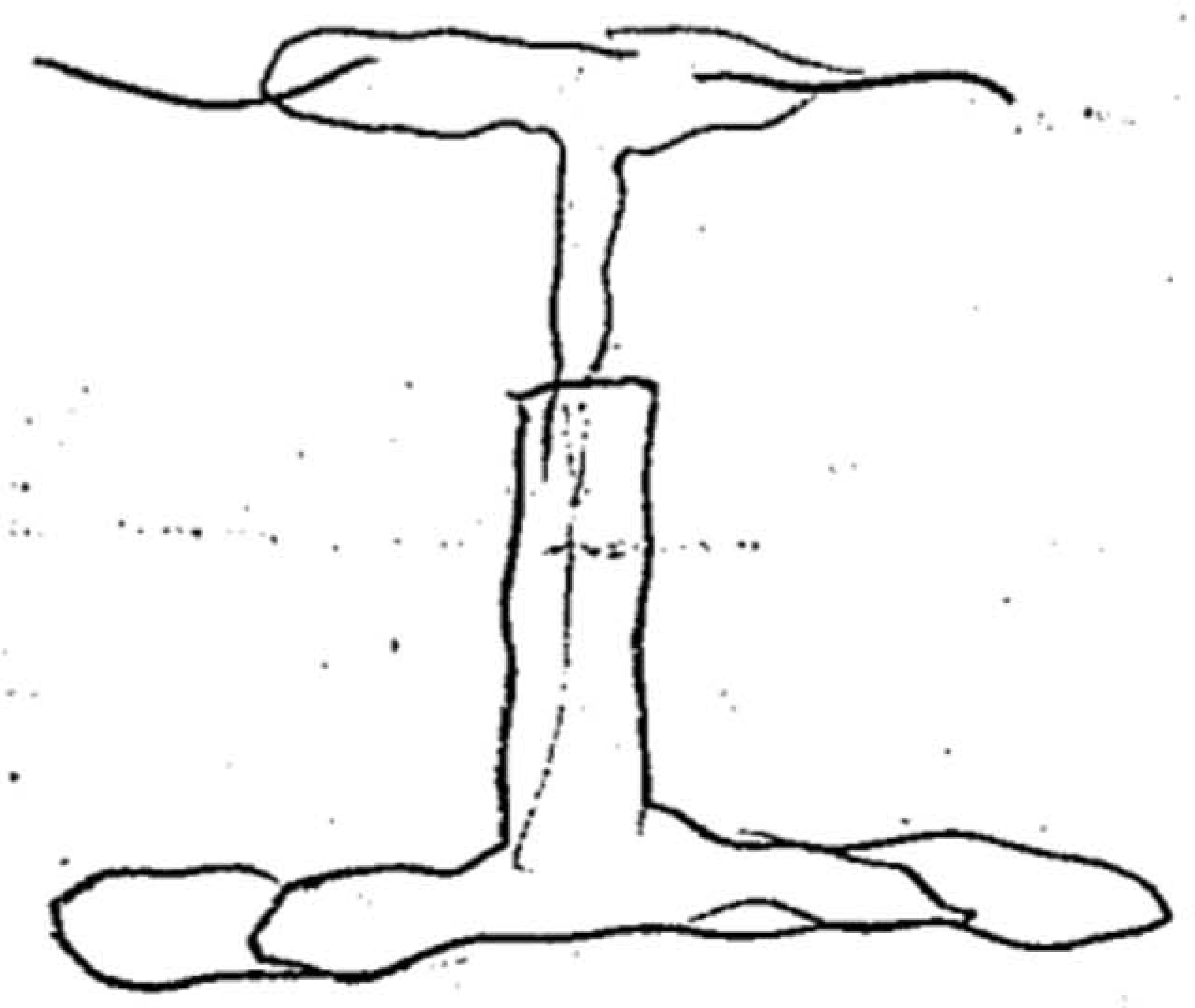
gas electrification apparatus

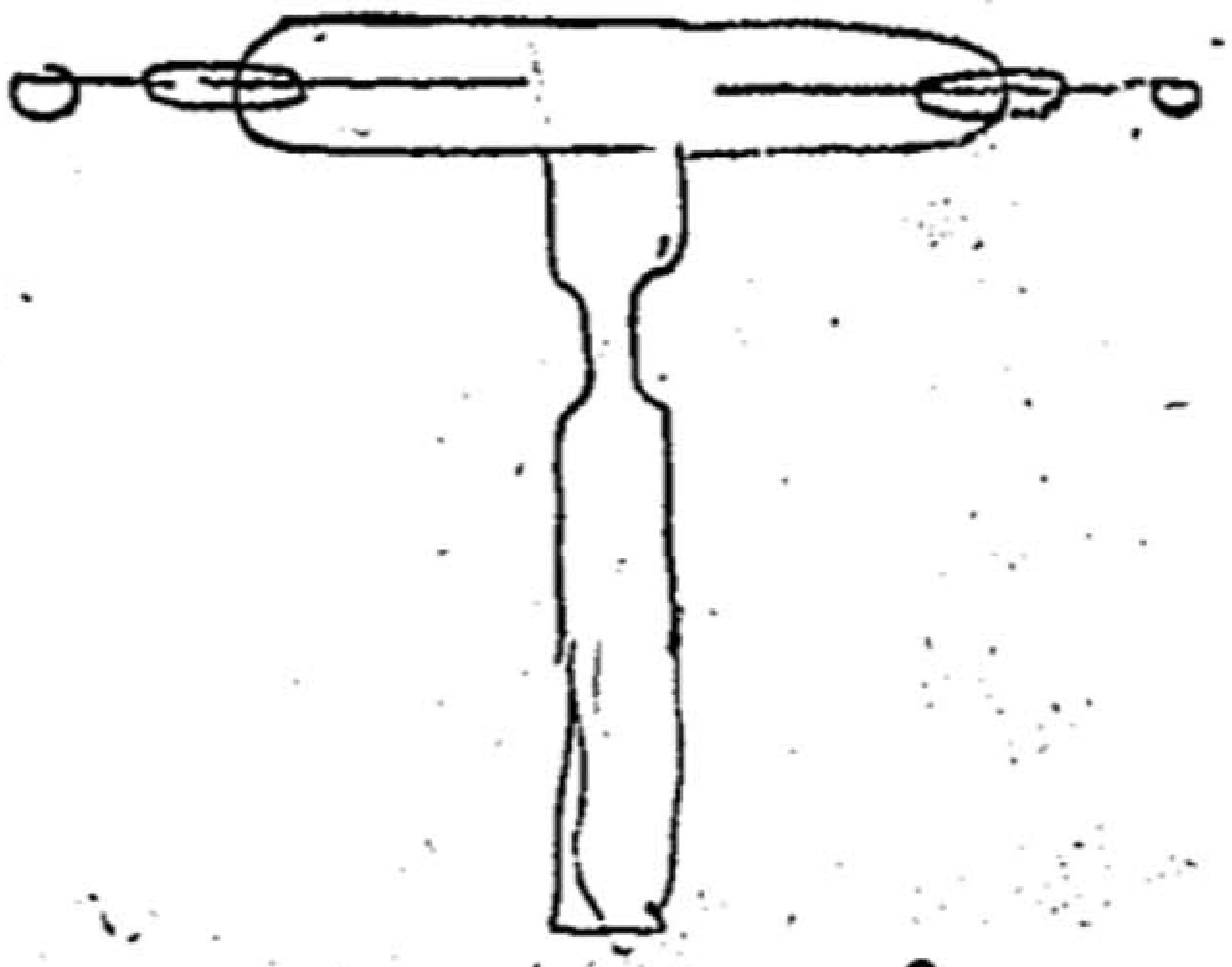
D.
1902

X-Ray

Number them

NO 1 Vacum
2 "
3 "
4 "
5 "
6 X Ray Vacuum





actual size

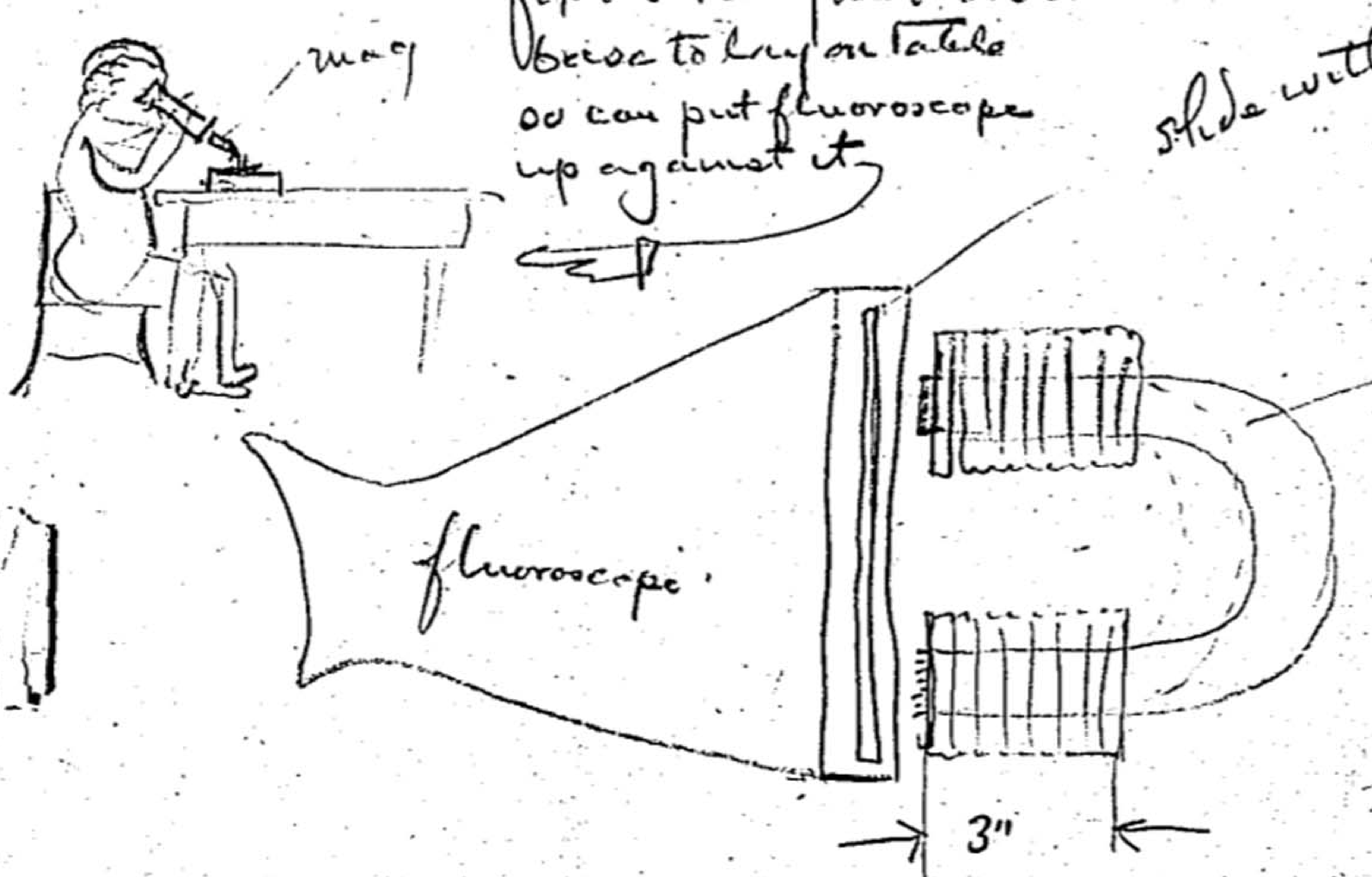
put 6 on the pump at once — when spark spreads out from the wire to glass seal one off — Then when it gets thinner seal another Then after a while another The last one to reach the X ray point

Heat all of them while exhausting

D
1902 "Fluoroscope"

Magnet for Fluoroscope

fix the magnet on a wooden brace to lay on table so can put fluoroscope up against it



core 1 inch dia made of No 20 or 22 iron wire & taped — then 3 or 4 layers of No 16 wire wound around —

Make the magnet so it will be about the same relative size to the fluoroscope you are going to make I will use the regular fluoroscope.

[ON BACK OF PRECEDING PAGE]

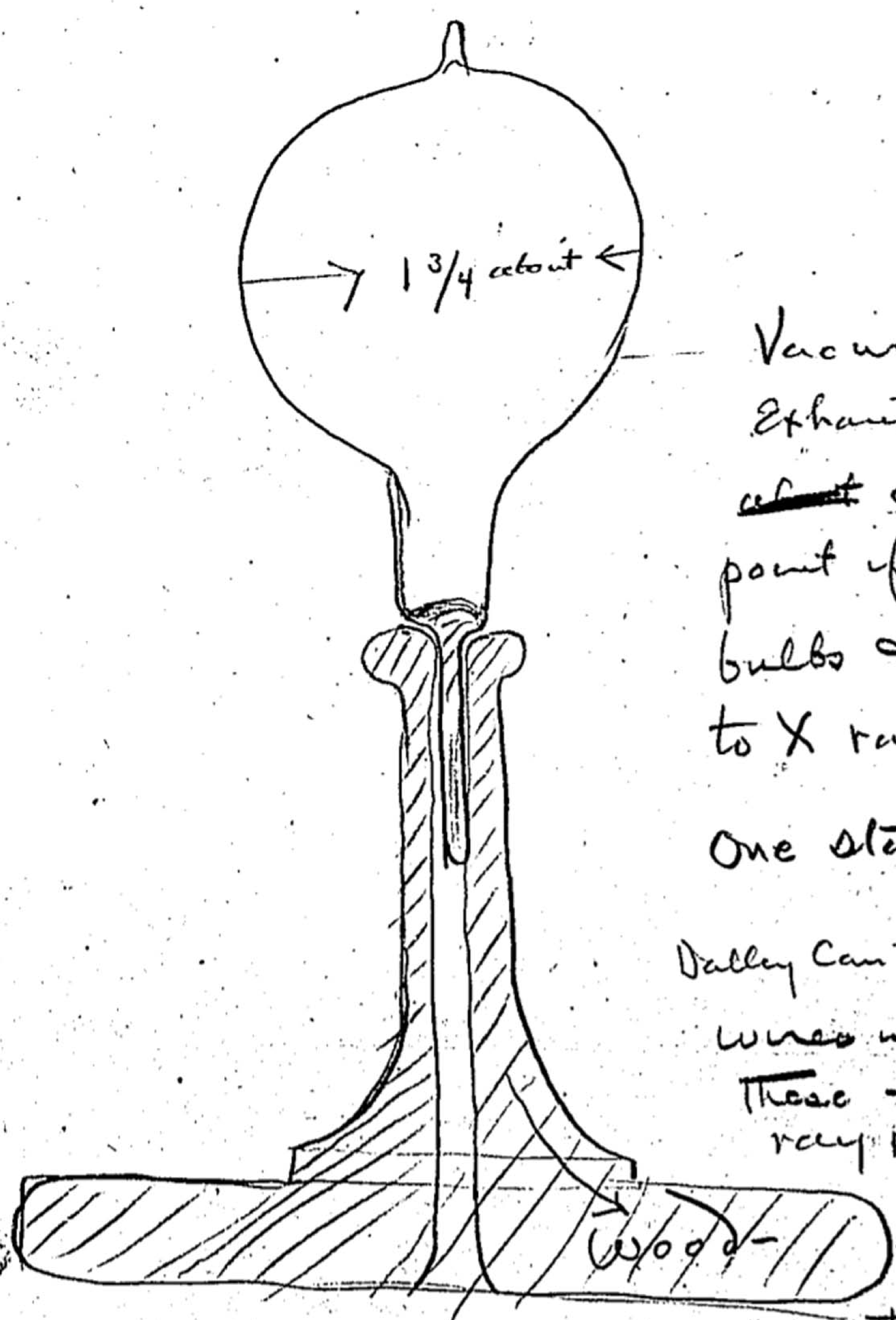
9:52
5G+
34
edisonmicrofil...

D
1902 X-Ray

actual size
50 of these

to be filled with Crystals
& Exhausted to X ray
Vacuum — these got ready
So I can fill with Crystals
when I return in April

D
1902 X-Ray



Vacum bulb
Exhausted very high
~~at~~ above X ray
point if possible for 3
bulbs & 3 bulbs Exhausted
to X ray point –
One stand will do

Dally Can put on a bulb with
wires in along with
these + tell when X
ray point is reached
then seal off
3 & then run
till tube shows
nothing & seal off
the other 3 =

Mark X ray point bulbs
X Ray bulb – the other Beyond X Ray

[ON BACK OF PRECEDING PAGE]

Dark Box for Etheric Force

Finnished Drawing
April 12 1902

Fin Model
April 28 1902

Slide 200
35842 2 grms Na Nit & – milg CaCl. ? ?

Slide 195
35559 2 grms K Molybd + 3 milg Uran Sulfate
? 35503 " " + 2 gr Calcum Borate
Strong 35473 " " + 2 grms CaCl.

Slide 203
quite strong 35971 2 grs K Nitrate + 2 gr Uran Sulfate
35970 " + 50 milg "

Slide 217
Very strong 20234 Iod-Sulphosalicylic acid
Strong 20214 Zn Salicylate
Strong - 20194 Fluorine ? ?

Slide 230
20834 Hydrastin Purinos
white 20821 Acenaphtene,
yellow 20820 Ammon Mellitate

Slide 213
20002 Diphenylamine
20001 Anilin green

Slide 249
37032 2 grs K Borate + 5 milg Uranvlsulfate

9:55
5G
34
edisonmicrofil...

Slide 183

Hetherington fusions deliquesced very little stuff left

34927
34933
34924
34940
34891
34947
34915
34862
34954
34857
34935

2 grms NaCy + 1 milg KFl
+ 1 " ZnCy
+ 25 " SrFl
+ 3 " KCy
+ 1 " Li Borate
+ 9 " CaPhos

+ 3 " CaCl
+ 5 " Ce Phos
+ 9 " AgCl
+ 9 ZnCy

Slide 181

Development Very little left

34953
34859
34858
34928
34941
34889
34883
34881
34901
34885
34886
34907
34911
34913
34931

Cant get hook out of slide –

Slide 180

34919 2 grms NaCy & 5 milg BaFl.
34916 & 3 " "
34936 & 25 " ZnCy
34904 & 3 " Ca Silicate
34670 2 grms K Arsenate & 50 milg Mercuric Chl.

Slide 58 —

3167 - Phos acid & $ZnCO_3$ & $PbCO_3$

Slide 75

1226 NaCl & MnCl
1227 " & PbCl.

Slide 66

Very Very Bright 2706 Hydrofluoric acid & NH_4OH & HgO.

Slide 35 —

4856 Thallium Cy & CaCy
4859 " & SrCy
4858 " & ZnCy
4860 " & NiCy
Bright 4868 Uranium Cy & HgCy.
4808 Thorium Cy & CuCy

Slide 54

6064 Tetrachloronaphthalic acid & $SrCO_3$, S
6000 P-Cresotinic acid & $NiCO_3$

Slide 170

34040	2 grms Na Sulfo.^{s}	+ 50 milg Sulphur
34021	2 " Na Sulphate	+ 3 " KCy

Slide 152

33589	2 grms Cadmium Iodide &	25	milg	BaFl
33652	"	1	"	Ce Phos
33587	"	3	"	Ba Fl
33604	"	1	"	Ca Borate
33596	"	50	"	Sr Fl
33634	"	1	"	Sulphur
33563	"	3	"	Uran Sulfate
33622	"	1	"	Zn Cy
33640	"	1	"	Hg Cl
33630	"	9	"	KCy
33598	"	1	"	KCy
33590	"	50	"	Ba Fl
33600	"	9	"	KFl
33599	"	3	"	KFl
33601	"	25	"	KFl
33564	"	9	"	Sulphur
33615	"	2 grms	----	Li Borate
33578	"	5	milg	Ca Phos
33654	"	9	"	Ce Phos
33574	"	1	"	Ce Phos
33628	"	1	"	KCy
33614	"	50	"	Li Borate.

Slide 189

Strong	35269	2 grms Na Tungstate	2 grms	Ca Cl
fairly strong	35305	"	2 "	Ca Fl
Strong	35293		2 "	Ca Borate
Strange	35290		9 milg	Ca Borate

Slide 160

Strong	35395	2 grms K Tungstate + 2 grms Ca Borate
Fairly Strong	35389	" & 2 " Ca Silicate.

Slide 161

Very Very strong	4263	Cuprocyanide K & Pb Cy
Strong	4254	" & Cr Cy
Strong	4264	" & Bi Cy
	4268	" & Ce Cy
	4265	" & Sb Cy
Strong	4260	" & Ur Cy
	4253	" & Al Cy

Slide 173

34311 2 grms Cu Iodide & 2 grms KCy

Slide 182 =

34938
34838
Hetherington Fusion 34819
34853
34934
Very little 34839
34840
34843
lift 34869
34893
development 34849
~~34888~~
34870

Slide 31

Strong

8079	P-Cressolinic acid +	K_2CO_3 +	$MnCO_3$
8075	"	"	+ $Cr_2(OH)$
8070	"	"	+ $BaCO_3$

Slide 172

33981 - 2 grm Na Sulphate & 2 grms Uran Su

Slide 68 ✓ possibly 68 + 69 transposed there are Uranium [illegible]

[illegible]

1042	[illegible] Chloride
1041	Acetate of "fesice" ;S see book
1040	Na Acetate
1039	" Robi " ;S
1038	Carb Ba
1032	Na Bicarbonate.

Slide 179

34743 2 grms K arsenate + 2 grm Uran

Try Radium on Chalk telephone - use thick Lead rotating shutter - also use telephone with different substances placed on diaphragm & with listening tubes throw Radium ray on & off the substances by a revolving lead shutter & see if can hear any sounds — Same with light from arc close to. Substances

Photo all slides using Barium Platinum Cyanide, Willemite, Tungstate Ca & Zinc Sulfide Screens to and —

delignment 34849
~~34888~~
34870

Slide 31
Strong 8079 P-Cresotinic acid + K_2CO_3 + $MnCO_3$
8075 " " + $Cr_2(OH)$
8070 " " + $BaCO_3$

Slide 172
33981 - 2 grms Na Sulphate & 2 grms Uran Sulfat

Slide 68 ✓ possibly 68 + 69 transposed there are Uranium minerals

1042	Venetian Chloride
1041	acetate of "fesice" ? see book
1040	Na Acetate
1039	"Robi" ?
1038	Carb Ba
1032	Na Bicarbonate.

Slide 179
34743 2 grms K arsenate + 2 grms Uran SO_4

Try Radium on Chalk telefone - use thick Lead rotating shutter - also use telephone with different substances placed on diaphram & with listening tubes throw Radium ray on & off the substances by a revolving lead shutter & see if can hear any sounds
Same with light from arc close to. substances

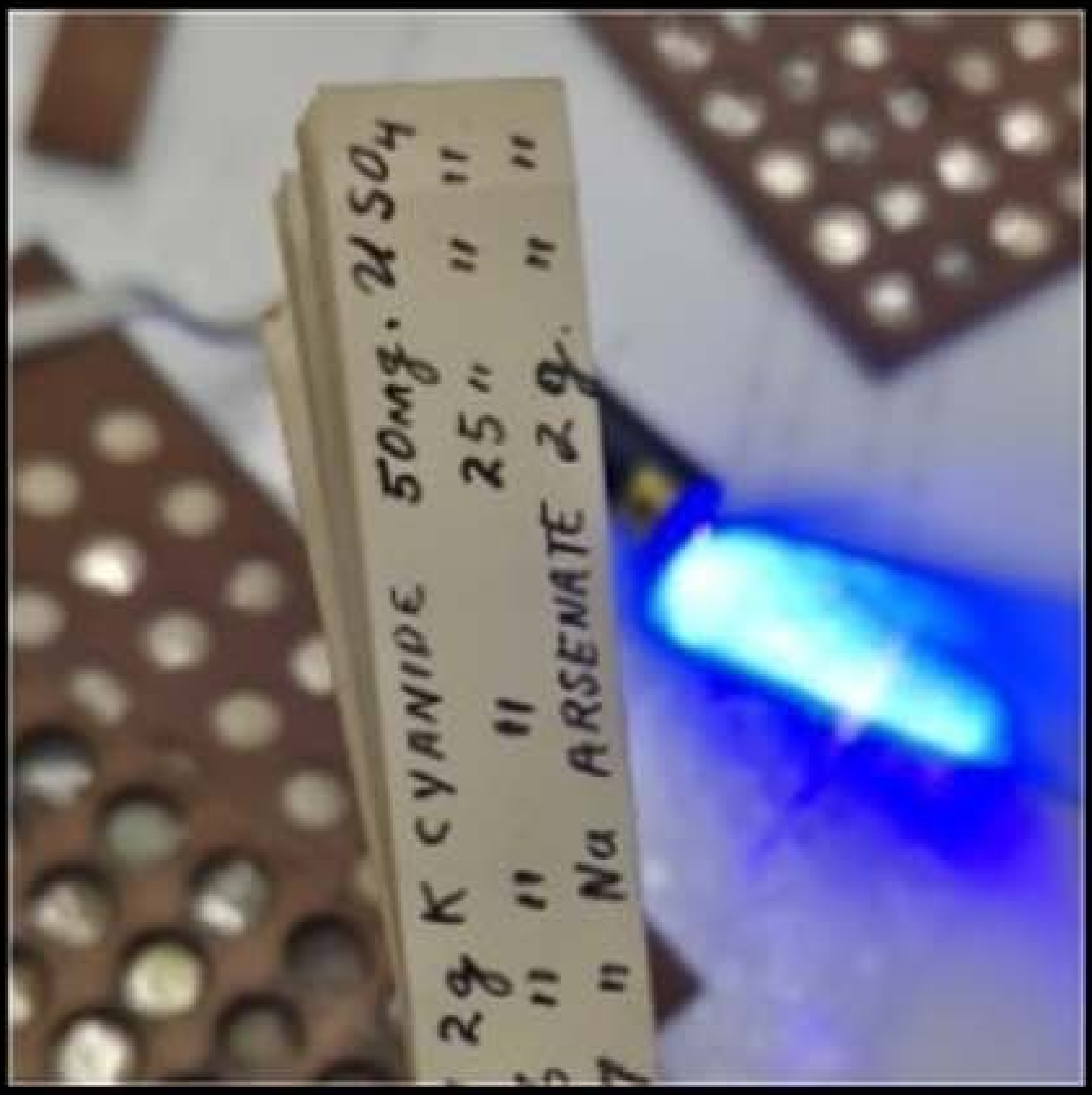
Photo all slides using Barium Platinum Cyanide.

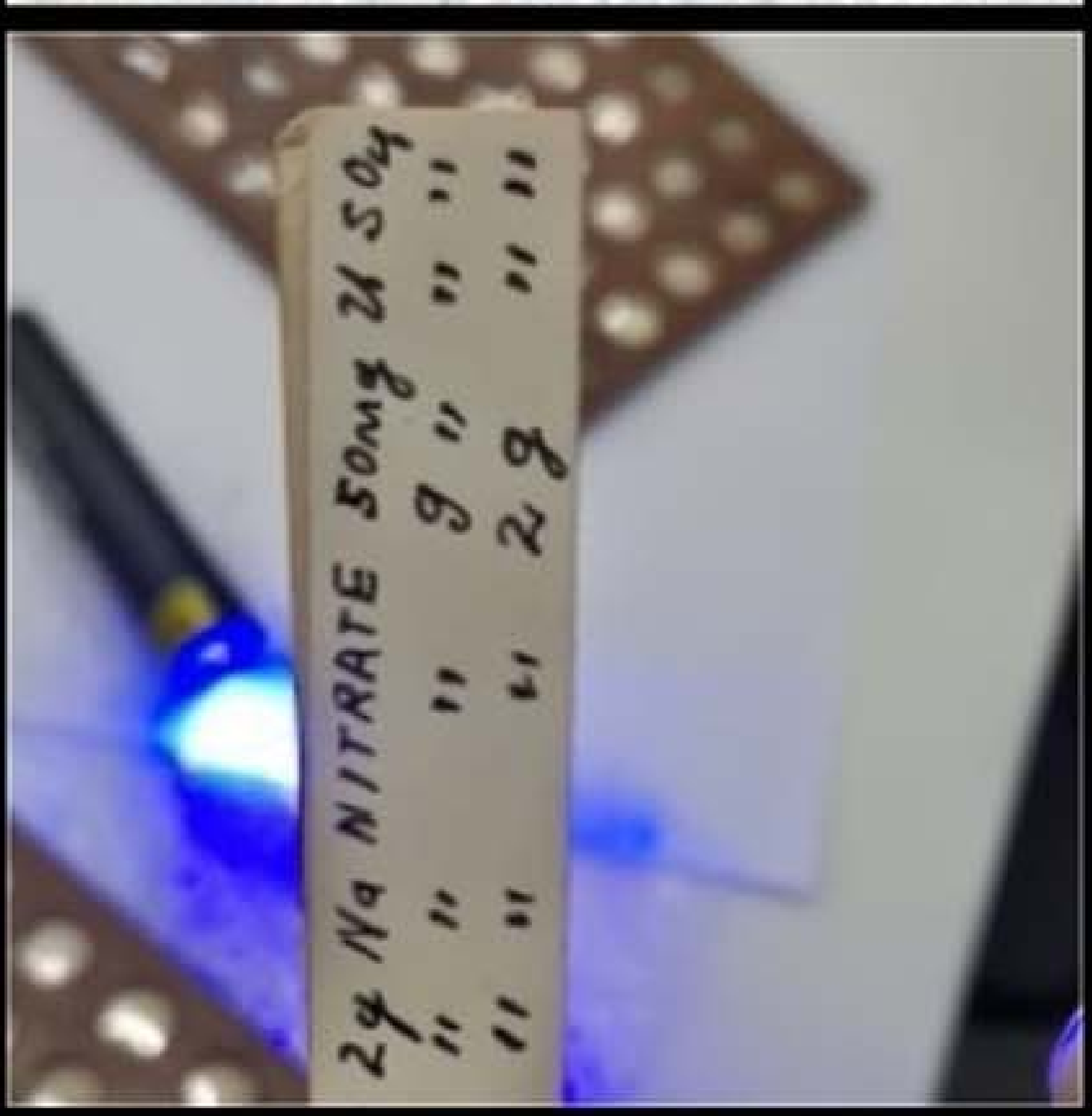
34440
3443
33981
33978

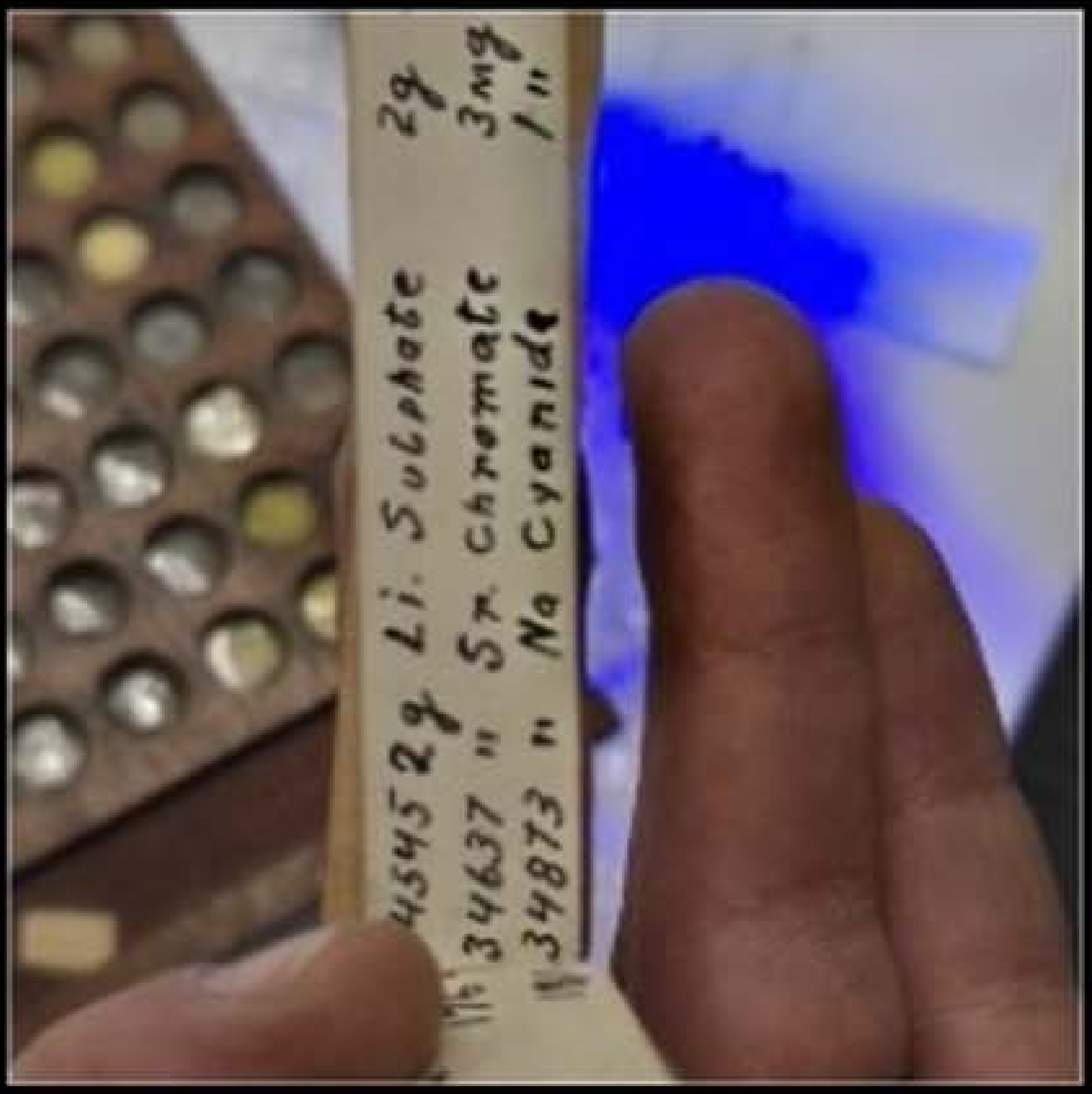
33981 2g Na. SULPHATE 2g $U SO_4$
33978 " " " 9mg. " "
34269 " Cu. IODIDE 2g. " "

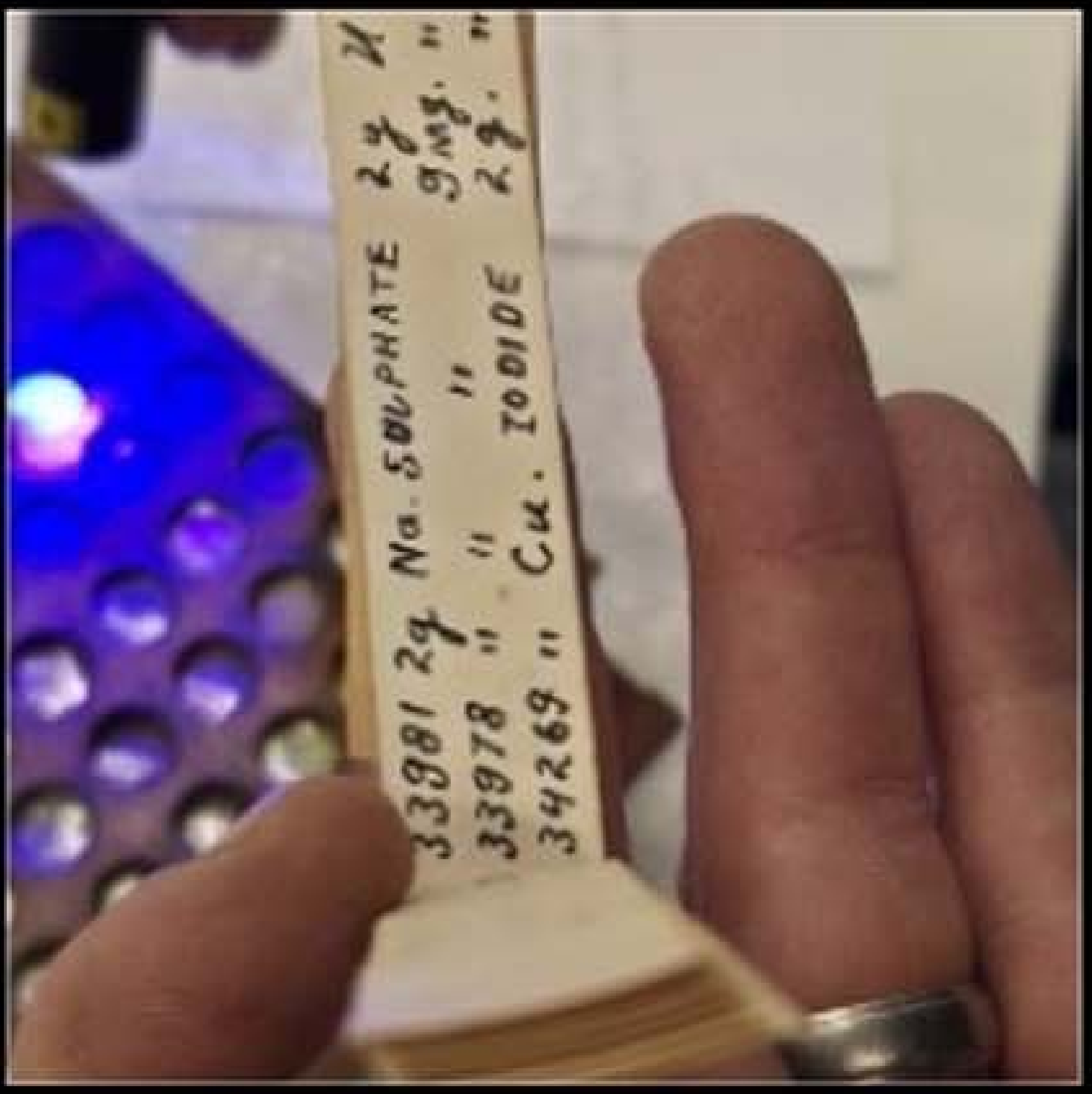
-VS-
WESTINGHOUSE, CHURCH,
KERR AND COMPANY

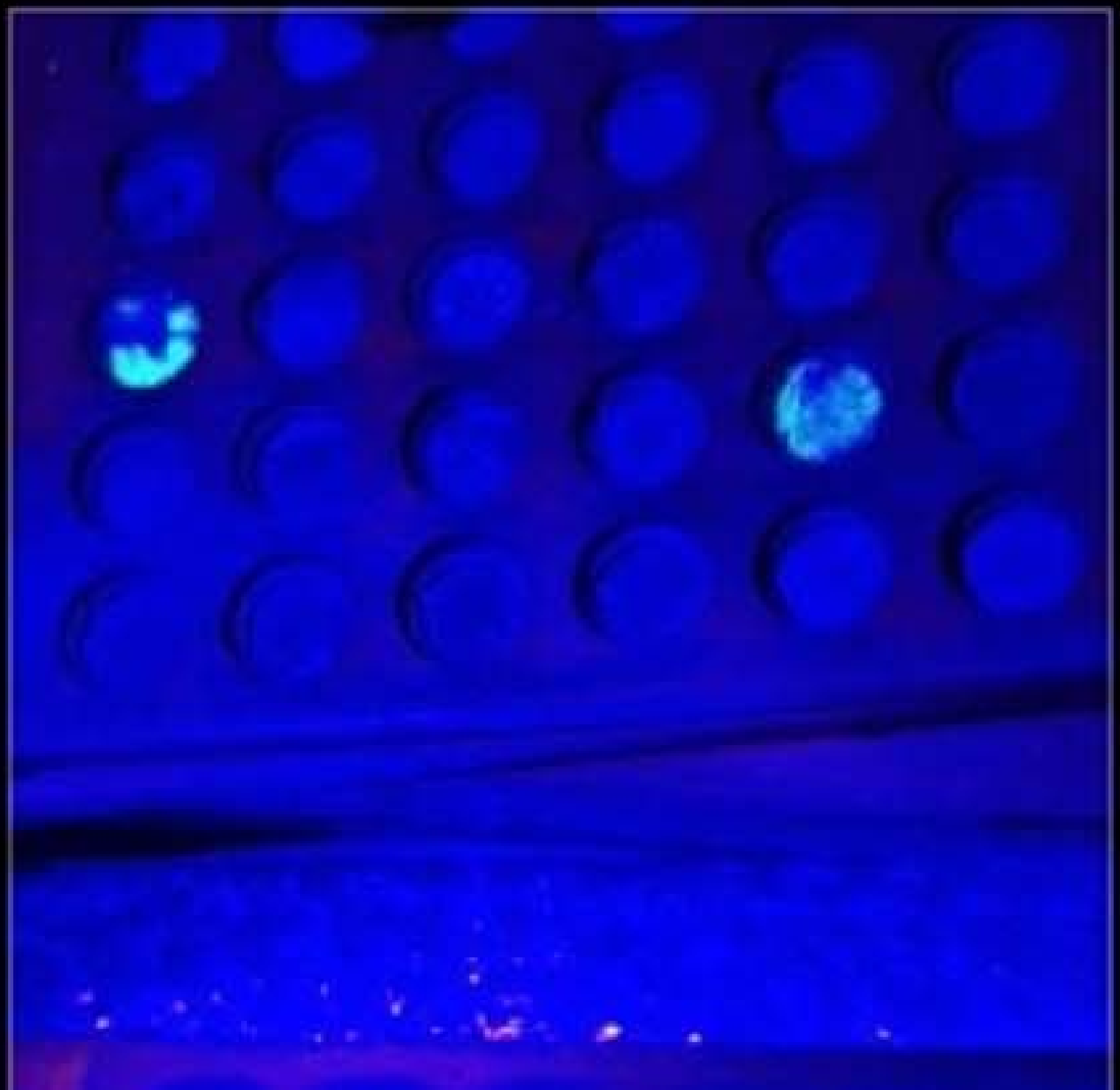
276 N

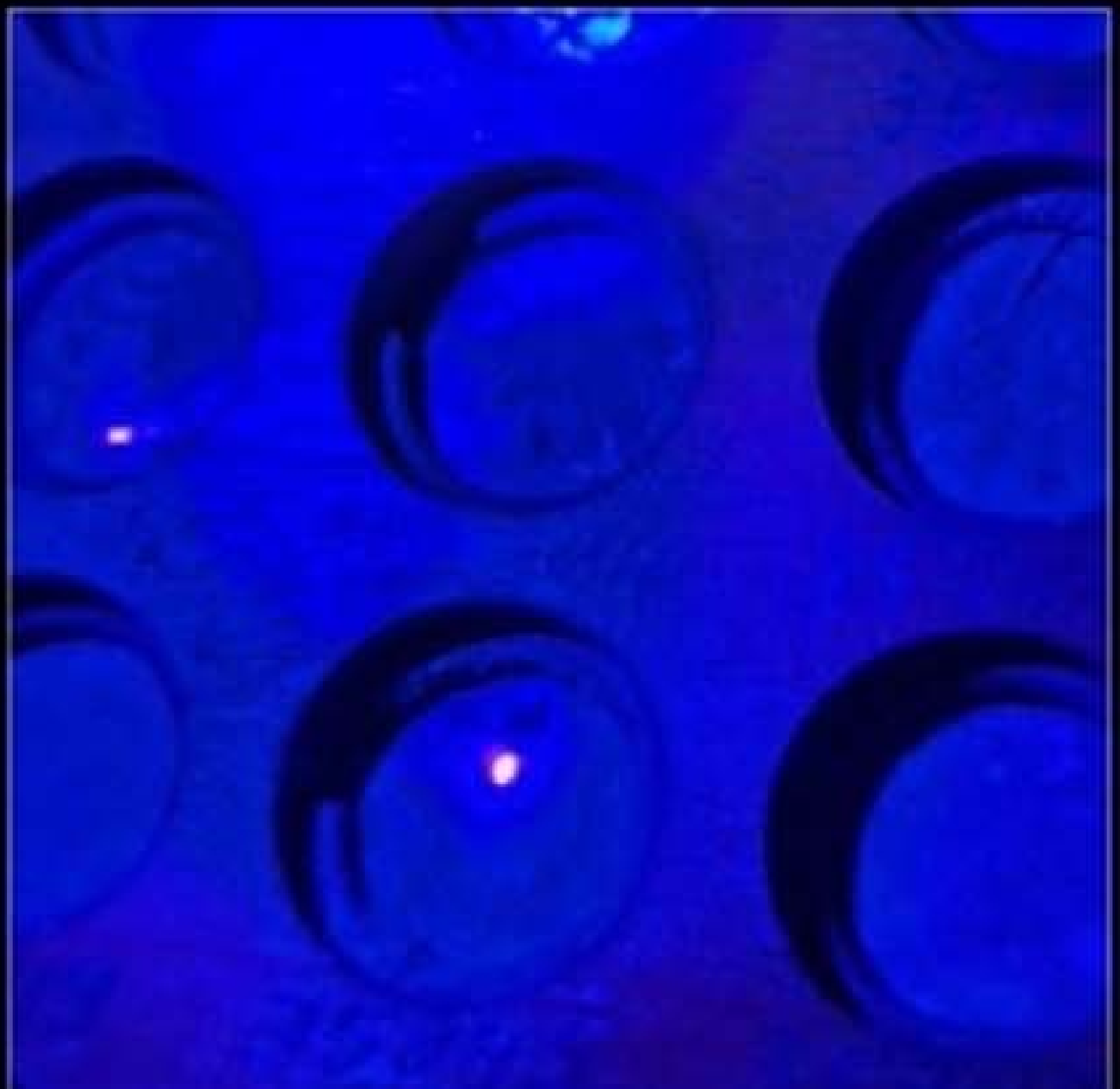

2g K CYANIDE 50mg. U SO4
" " 25" " "
" Na ARSENATE 2g. "


2g Na NITRATE 50mg U SO4
" " " 9 " "
" " " 2g "


34545 2g Li. Sulphate 2g
34637 " Sr. chromate 3mg
34873 " Na Cyanide 1"


33981 2g Na. SULPHATE 2g U
33978 " " 9mg.
34269 " Cu. IODIDE 2g.





This wants to be well made as there will be several hundred slides to go in & out, & it must be Easy & quick to change them —

The Carpenter is to make 300 slides of which 50 slides are to be put in a box. This will make 6 boxes these boxes should have cleats so Each slide when put in box goes in Easy & dont touch the other slides. The box should have a Cover & handle —

There are I think 40 or 50 places on Each slide for Crystals

300
350

This will give about 14000, different crystals, two mica washers are used for each hole, use only Clear mica & make a punch, also a little device to make the wire ring cheaply—